ENERGY FOR A JUST AND SUSTAINABLE SOCIETY

anticipation

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ENERGY FOR A JUST AND SUSTAINABLE SOCIETY

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CHRISTIAN SOCIAL THOUGHT IN FUTURE PERSPECTIVE

Papers circulated by Church and Society, World Council of Churches, 150 route de Ferney, 1211 Geneva Switzerland

Photo and design: John Taylor and Yushi Nomura, W.C.C.

NOTE:

The theme of this issue of *Anticipation* reflects the growing awareness of world energy as a social and ethical problem. Ecumenical interest in the nuclear power debate has intensified interest in the wider energy question. The papers and essays in this issue represent the many different aspects of the problem which require attention in the churches.

- The opening paper on "Energy for a Just and Sustainable Society" was prepared at the May meeting of the core members of the new Working Group on Church and Society at Glion, Switzerland, May 15-20, 1976. A group of energy consultants was also present and helped provide the necessary technical information on energy policy. This group also prepared the Draft Plan and Manifesto for the proposed action programme on "Energy for my Neighbour" as a practical way to involve the churches in the search for a more just distribution of world energy resources.

- The papers on "The Nuclear Energy Debate in the Churches" and the Abstract of a paper on "Public Acceptance of Nuclear Power" reflect the continuing ecumenical discussion of the expanding use of nuclear power. The first is a survey of responses to the Report of the Ecumenical Hearing on Nuclear Power, Sigtuna, Sweden (June 1975), which appeared in *Anticipation* No. 22.

- The recently published 237-page report of the Royal Commission on Environmental Pollution (U.K.) on *Nuclear Power and the Environment* will be widely studied for its views on nuclear energy. Sir Brian Flowers who chaired the Commission is a distinguished physicist and rector of Imperial College of Science and Technology, London. The final chapter of the report, "Nuclear Power and Public Policy", is reproduced here for the benefit of readers who may not have access to the entire volume.

- The energy question has provoked a steady stream of imaginative reports and essays and we are pleased to reproduce four here. The authors are:

  Prof. V. Lawrence Parsegian, Professor Emeritus of Physics at the Renseelaer Polytechnic Institute in New York State. He submitted his paper in response to the ecumenical debate on nuclear energy.

  Dr Garret Hardin, Professor of Human Ecology at the University of California, Santa Barbara. His article was published in *Skeptic* Magazine which has kindly permitted its reprint here.

  Dr Cesare Marchetti, Deputy Leader of the Energy Project of the International Institute for Applied Systems Analysis, an inter-governmental programme with headquarters at Laxenburg (near Vienna). We are grateful to the leaders of the World Hydrogen Conference for permission to reprint Dr Marchetti's interesting paper.

  Prof. A.K.N. Reddy, at present on assignment with the United Nations Environment Programme (UNEP), is a scientist from India ordinarily attached to the Indian Institute of Science, Bangalore.

- The final item in this issue is a programme prospectus prepared by the new Working Group on Church and Society on the further ecumenical study of Faith, Science and Society. These plans were approved by the Central Committee meeting in Geneva in August 1976. We welcome comments and suggestions on them.

Paul ABRECHT

ENERGY FOR A JUST AND SUSTAINABLE SOCIETY

Report from the Working Group on Church and Society and a Group of Energy Consultants

Glion, Switzerland – May 15-20, 1976

I. FINDING THE RIGHT PERSPECTIVE

1. General

Society can be thought of as built mainly of materials, energy, and (in its Greek sense) *nous*. This last is the critical ingredient, not only what has enabled us to utilize larger and larger amounts of the other two, but also the only indefinitely expandable *per se*.

We ask how a more just and sustainable society can be created out of these things and are particularly concerned here with energy. First, what about the relation of energy to social justice ? This seems to us in general to be fairly clear, and details will be given below. In brief, the developed nations use more than they should and developing nations use much less than they need. On balance, the world energy supply should rise, at least for a significant time, during which social justice and equity become more or less ubiquitous. But how much energy ? Of what kind ? In what places ? All this can be worked out, provided a consensus develops on what "sustainable" really means. The concept has meaning only in terms of a shared societal time perspective. How long a time ?

2. A Very Short Time Perspective – a Non-Sustainable Society

At the meagrely short end, for example 25 years, re-distribution of present petroleum and possible intensified use of natural gas and coal would suffice. Neither nuclear nor solar energy nor any other major option need be developed. Energy conservation, rational utilization and increased efficiency would not enter into consideration.

The trouble with this view is that disaster impends in (so to speak) the 26th year. No plans will have been made for what to do when the oil and gas run out; no options for longer terms will have been carefully prepared, and one can imagine different sectors of society warring over the remaining scraps. Normal economic time perspectives are short, usually even shorter than 25 years, while many other social decisions carry a much longer time perspective, e.g. housing, transport and industrial manufacturing. The time is much too short to achieve any appreciable redistribution of worldly wealth; thus social justice is also sacrificed. At this moment, we live in the future of 25 years ago, when today's energy problems were beyond the horizon of thought, and so we are in trouble.

3. A Longer But Still Insufficient Time Perspective

Suppose now a 50-year time perspective. Issues and actions will be quite different. It is not just a question of making a 50-car train out of a 25-car train by merely adding 25 extra cars. The train itself must be different.

World-wide, petroleum and natural gas will be substantially depleted unless other options have meanwhile been introduced; coal assumes a more important role, and brings a multiplicity of its own problems; present-day nuclear fission reactors, while not absolutely essential, may turn out to be more socially and economically acceptable, than many fossil fuel options. The carbon dioxide level in the atmosphere (from burning fossil fuels) will have risen far enough to bring us to the brink of substantial climatic changes of uncertain nature. Even so, some energy options (controlled fusion, breeder reactors, for example) can still be ignored. Conservation and rational utilization become important, partly through simple economic attraction, and partly by the opportunity to move towards the redistribution needed for a more just society.

Thus we see how the 50-year scenario is no mere extension of the 25-year one; it has elements which require solution (e.g. societally acceptable development of new coal technologies, technologies and ethics of conservation, climatic studies), and the development times required for such solutions are much longer than is generally recognized. Present nuclear fission technology required 25 years, a period typical of most major options, even after the basic science is understood. This extended period arises because of the necessity of building pilot projects, production prototypes and finally, useful installations. Sometimes these epochs can be telescoped, but the total cost tends to rise alarmingly as construction outstrips understanding.

Perhaps surprisingly, actvities must start now for a 50-year time perspective, just as for a 25-year one. But the activities will be different, future options will be greater, and the opportunity will exist to save some (not much) of our petroleum and natural gas for later years.

But here too the life of the society will be fleeting: dependence on fossil fuels makes later climatic changes inevitable. All fossil fuels will run out; and the three truly sustainable possible energy sources – solar, fusion and fission – will not have been properly perceived, let alone developed. The society will not collapse in the 51st year, but later transitions will become very difficult.

4. The Real Sustainable Future

Now suppose a 100-year (or preferably longer) time perspective. Petroleum and natural gas will make such a small contribution, averaged throughout the period, that serious thought should be given to desisting from their use as soon as feasible (25 years ?). Continued principal dependence on any fossil fuel brings so many difficulties in its train that coal itself (the world's largest fossil reserve) will appear in its proper light, as a raw chemical resource for present and later ages. More rational energy utilization, increased efficiency, and other energy minimizing strategies will dominate the scene. On the supply side, the three long-term world-wide options appear: solar power, nuclear fission, and nuclear fusion. These can and should be augmented by attractive regional energy sources, whose importance will vary with time: biomass (especially for some favoured tropical nations), wind power (especially for small applications where its variable nature can be tolerated), geo-thermal power (in tectonically active areas, such as the Pacific rim and the Mediterranean rift), and waves (some maritime locations).

This time perspective also requires early decision about many items, and a conscious beginning; otherwise one of the shorter-time scenarios comes into being by default. Oil and coal cannot be saved unless the main supply alternatives are available soon. But all three have peculiar problems. Controlled fusion is scientifically and technologically very complex, may be late, and might not even be practically achievable. Solar power will have large low- and intermediate-technology uses of great value (direct solar heating and cooling of differently designed buildings, for example); bulk electric power from sunlight will be several times more expensive than other options, unless there are scientific and/or technological advances not now foreseen. If nuclear power is to have long-term prospects, it must be via breeder reactors (or at least nuclear fuel generating devices), because the world's resource of naturally fissionable U-235 will last probably not more than 50 years – something like petroleum and natural gas. But to permit a well-ordered nuclear future, breeder options should be developed during the next 25 years or so.

5. What is the Answer at this Point ?

We have already given it: We believe that the only one that ensures a really sustainable society – i.e., a civilization worthy of the word – is the long-time perspective. It provides maximum insurance against inadvertent denial of options to future generations; it best facilitates continual redistribution of energy as we work toward a universally just society, which will take much time; it makes us partners in a usufruct contract with nature, even though we cannot see well enough to read all the signatures.

That long-term view brings with it a complex series of benefits and costs. Typical benefits are a recognized early strong start on rational energy utilization and efficiency everywhere; it draws attention to energy from biomass, select geothermal areas, urban and other societal wastes (with much environmental improvement) and other specialized sources; it helps to ensure lasting environmental quality and resource availability (with much more recycling). The costs are (predictably) those of developing for the world a series of long-term options probably not all of which will be implemented. The main three, as said before, are bulk solar power, nuclear fusion, and nuclear fission (including breeder variations). This raises two important questions: (1) Will the nations, separately or together, consciously embark on a programme of option development (as insurance, so to speak), knowing that not everything will eventually be used ? (2) Given (1), when the time comes to decide, will the winnowing-out truly be done, despite well-known tendencies for large projects to generate constituencies and to self-perpetuate ? Because it will cost (say) 10-20 billion dollars to carry each project to the stage of mature decision, these questions are important. But consider also that the world spends about 500 billion dollars annually for energy, and that amount will increase; viewed that way, a range of energy options to meet diverse demands of different sectors is affordable.

Do any precedents exist for such an activity ? Only on smaller scales. But the U.S.A. spent two billion dollars on supersonic commercial air transport before dropping it without recriminations; and much larger sums seemingly vanish into military "insurance" of more questionable value.

Thus we lay out the issues in a first general overview. The parts cannot be separated and the assessment must be relative. We find: rational and efficient energy utilization (implying studies of future growth, needs, and demands); many regional sources of varying magnitude (biomass, wastes, geothermal, winds, waves, etc.); coal for part of the intermediate term, to be used in new ways; oil and gas to be cherished or soon exhausted; and the potential big three: solar, fusion, and fission. All have peculiar difficulties and advantages economically, environmentally, politically, and technologically. Only in the light of comparative assessment will we find a rational decision about nuclear power.

II. THE POTENTIAL BIG THREE

1. Nuclear Fission

According to various assessments of large-scale energy supplies, it appears that no known sources are likely to be clean, safe *and* low cost. It is reasonable to hope that fusion, solar and geothermal energy will turn out to be clean and/or safe, but there are certainly no guarantees that these can be made available at low cost. Currently there is substantial uncertainty whether fusion energy will turn out to be technically feasible, let alone economically competitive.

For the most part, the industrialized countries depend for energy on fossil fuels; in many developing countries, the pattern of dependency is not so clear cut and traditional sources (such as wood products and animal waste) are still a major source of supply. In several countries, deposits of coal and shale are available in large quantities, but without extraction or conversion methods *in situ* the process will continue to be both polluting and expensive. Against this backcloth of uncertainty, many industrialized countries have already begun to transfer their dependency from fossil fuel to nuclear fuel while acknowledging, openly in some cases, that this poses safety and environmental problems without any real precedent.

For large-scale energy supplies in major industrial countries there appear to be no near term alternatives to fossil and nuclear fuels. One way or another, it is recognized that most of these countries will probably resort to major efforts over the next 30-50 years to reduce the overall demand for energy. Despite the prospects for energy conservation, many countries are now obliged to plan for a transition from fossil to nuclear fuels based at this moment on the known commercial systems for nuclear fission.

This transition will be governed by the following constraints:

i. The limitations on proven reserves of oil and gas;
ii. the limitations on reserves of low-cost uranium;
iii. the limited industrial capacity for the construction of nuclear power stations;
iv. the drain on capital resources that full implementation of the option could entail.

There are circumstances under which it is argued that the fast breeder reactor will open up a qualitatively new dimension of fuel supplies, since it makes possible the extraction of roughly 100 times more energy from a given amount of natural uranium than can be achieved with existing thermal reactors. It would then be economically feasible to exploit deposits with a very low uranium content, thereby removing one of the principal resource constraints on energy supplies. While national energy planners recognize that other major constraints may govern the transition to a breeder power economy, viz., the uncertainty about reactor safety, the difficulty of handling a large-scale fuel cycle based on either plutonium or thorium, together with environmental and ecological effects, these factors do not dominate their minds. The proof of commercial viability of the fast breeder reactor is still in the technical domain as far as the planners are concerned, but it is essential that the future significance of the breeder reactor should now be more widely appreciated.

Since the availability of global thorium is as great, if not greater than that of uranium, and the fuel reprocessing technology for separation of U-233 is viable with further research and development work, some advantages exist from a long-term radiological hazards point of view if the U-233-Th-232 breeder cycle is adopted rather than the Pu-239-U-238 cycle. Some off-setting disadvantages exist also, but a proper comparison has still to be made. The planning of the nuclear power programme of any country through either cycle, however, is dependent on the initial plutonium inventory.

The other key element in this transition state might be the high temperature reactor, which would supply process heat for the production of non-electric secondary energy, e.g., in the form of hydrogen. It will not be possible to rely on electricity alone as the secondary energy carrier, for reasons of efficiency and of end use; that is, electricity is an expensive source of energy for transport, many industrial uses, and for heating. The transition away from fossil fuels in this scenario would thus involve a combination of fast breeder reactors and high temperature reactors which could together supply all demands for electricity and non-electrical energy. The only natural resource constraints would then be thorium and natural uranium.

The strategic choice already outlined will be explored by many industrialized countries during the coming decade. The Church and Society programme should include an assessment of the particular problems that will be encountered including the social problems involved in the siting of these reactors and the safe management of the fuel cycle.

2. Solar Energy

While there is uncertainty about the best choices for large-scale energy production in industrialized countries and while the possibilities for decentralized energy systems for urban communities seem remote, there is a serious need to examine the possibility of solar energy conversion for those areas where this source has been largely discounted. Both small-scale installations (e.g., small water heaters) and large-scale ones (e.g., solar electric power plants) will be important. The discussion here focuses more on large-scale conversion, but not exclusively. There are many specific technical parameters which must be reexamined, including the availability of unused land, the levels of insolation (or solar flux; dispersed as well as undispersed incident solar radiation) and the overall environmental impact of the collection and conversion process.

It seems unlikely that, during the transition from fossil fuel to a large dependency on incident solar energy, should this become a feasible alternative, whole plants can be built entirely independent of fossil fuel generation of electricity. The coupling of large-scale energy devices to existing energy systems will therefore clearly feature as an essential part of the transition state. By operating a solar power station, it should be possible in a coupled situation to reduce the oil consumption in a fossil fuel power plant and hence the cost and the burden of dependency on oil.

Although hard data on solar energy cost are not available at present, comparison of costs can be made in the following way. If investments in the solar receiver are made at the level of $60 per square metre and the total solar insolation is around 1200 kwh per square metre per year at a particular location, then the payback time of the investment can be made directly competitive with the price of oil (assumed to be $10 per barrel) over a period of 40 years or so. The challenge is therefore to be found not so much in producing a watertight economic argument (after all, this is much the same situation that nuclear power was in as little as 10 years ago in many countries) but in integrating solar energy systems into existing energy systems. The problem of energy storage can be minimized on those countries that already employ pumped storage in connection with hydroelectric schemes; for the rest, new methods will have to be developed.

Alongside this prospect for integrating solar energy capture with direct fossil fuel conversion, goes the need to study localized space heating by solar energy right down to the level of the individual household. Water heating could perhaps be tackled first, if only because hot water is required all year, thus ensuring a high use factor and making the operation more economic. For space heating the siting criteria for the utilization of these various possibilities can be categorized as follows:

1. Locations suitable for development of residential and communal heating systems, without energy storage capabilities, using existing technology (relatively low insolation levels, but above 700 kwh/m^2 per year).
2. Locations for large-scale hybrid facilities (conventional power plant with auxiliary solar system) without energy storage, using some new technology levels, near or above 1000 kwh/m^2 per year).
3. Locations for large-scale solar energy conversion facilities, with energy storage capabilities, using advanced technology for major systems control (high insolation levels, near or above 2000 kwh/m^2 per year).

The large-scale operations in areas of high solar insolation could also perhaps be used for hydrogen production, if the concept of the "hydrogen economy" is adopted for non-electrical energy distribution. The feasibility of these linked systems of solar energy conversion is now actively under investigation in many countries, and preliminary results suggest that the economic point of breakeven is already at hand. The significance of this technology for developing countries with favourable conditions for using solar energy has not been properly assessed. Trends in the industrialized countries seem to indicate that a variety of such devices will be developed within the decade 1975-85. While the deployment of advanced technologies, especially those using solar energy, would not directly benefit the developing countries, experience so gained may be used, with appropriate modification, in tackling energy problems and requirements of these countries.

3. Nuclear Fusion

For the long term, controlled fusion must be included, although its eventual reality is still unsure. Even with the best of luck, it will not be generally available before the year 2000. Technologically speaking, controlled fusion will be more difficult to develop than any fission technology, roughly in the ratio that fission technology is more difficult than simple burning of coal.

Fusion, if achieved, promises to be environmentally and societally much more acceptable than nuclear fission. No radioactive wastes arise from its direct products; nevertheless, the system uses tritium (which is radioactive) and the structure of the fusion reactor will become highly radioactive because of irradiation by high energy neutrons. Thus problems of containing tritium and dealing with a radioactive structure exist. No comparable scale of danger exists of a fusion reactor suffering a large-scale accident and releasing radioactivity to the public, comparable to the worst scenarios envisaged (with very low probability) for fission reactors. In summary, fusion might be environmentally a thousand times less hazardous than fission, but that number should, in the absence of any actual developed device, be taken only as a guide.

No sabotage or weapons proliferation issues appear to exist with fusion. The resources will suffice for any technological age. The cost is yet highly uncertain.

Thus we can say about controlled fusion: many nations have aggressive development plans and hopeful guide-dates; but we can also say that we cannot now predict the outcome.

4. Comment

While only three major strategic choices have been considered for purposes of illustration, there are obviously many more alternative combinations that remain to be worked out for different countries. These energy balances will undoubtedly include wind, ocean thermal, wave and geothermal energy, but a future long-term dependency on at least one of the three major sources would seem to be necessary for countries both with a developed and a developing industrial base.

III. NUCLEAR ENERGY: IMMEDIATE ISSUES

The following comments can be made regarding the nuclear energy situation since the Sigtuna Hearing. The uncertainty over the future contribution of nuclear energy to the overall balance of energy production in most industrialized economies is no nearer to resolution. Nevertheless some new tactical and strategic elements in the assessment will undoubtedly have a bearing on the status of nuclear energy when viewed at an international level. The tactical situation has changed as a result of important initiatives that have been taken or are in the process of being taken in different countries, particulary in those developed countries, viz. U.S.A., France and the Federal Republic of Germany, which must be regarded as having the major influence in the world commercial market for nuclear energy. These new elements will now be considered in turn, along with the appropriate list of questions that must be asked:

1. Attempts to Control Use of Nuclear Technology

A group of seven nuclear exporting nations – the U.S., U.S.S.R., Canada, France, Germany, the U.K. and Japan – has revealed terms on which the three so-called "sensitive technologies" of the nuclear fuel cycle can be exported. These technologies are the enrichment of uranium and the reprocessing of spent nuclear fuel, both of which can yield material suitable for the production of nuclear weapons, and the refining of heavy water, which is a key requirement for the operation of certain types of reactor. The terms of the agreement as currently negotiated are as follows:

a. The exporting nation will require an assurance that nuclear technology of any description will not be used to manufacture a nuclear explosive for any purpose, including the "peaceful" nuclear explosives designed specifically to perform an earth-moving task. (This stipulation was not made before in contracts negotiated by those nations with all others which had not yet signed the Non-Proliferation Treaty).
b. The exporting nation will require an assurance that exports will be adequately safeguarded against the risk of theft or sabotage. (This reflects the growing public concern over the activities of terrorists and dissident political groups).
c. The recipient nation will be required to give assurances that the technology will be transferred to another nation only under the same international safeguards that cover the initial transfer of technology.
d. The exporting nation will require assurances that these safeguards will apply to any replication of plants based on the original transfer agreement and completed within a time scale of 20 years from that date.

Some, but not all, of these are included in the International Atomic Energy Agency stipulations in the negotiations.

These assurances will of course only serve to reduce the chances of these sensitive technologies being misused. In no way can they prevent a nation that is sufficiently dedicated to making nuclear weapons from acquiring that capability. For example, there has been direct criticism of the contractual arrangement whereby the Federal Republic of Germany undertook to provide Brazil with virtually a complete nuclear industry, including all the necessary fuel cycle technologies. However, under the new agreement on replication the Brazilian Government has agreed that, for a period of 20 years after receiving details of the German "jet nozzle" process of uranium enrichment, and of reprocessing expertise, it will not use them to build plants of its own except under international safeguards.

Such agreements are perhaps not entirely consistent with the principle of sharing nuclear technology among all nations. The necessity to maintain international safeguards while allowing the unrestrained expansion of nuclear energy for civil purposes is a major paradox at the centre of the nuclear power debate.

2. Proposal for Establishing Regional Fuel Centres

The second tactical innovation that is being actively investigated by the International Atomic Energy Agency is the concept of regional nuclear fuel-cycle centres. This incorporates the conventional economic argument that there would be direct benefits to nations through international cooperation, particularly relating to improved manpower utilization, more efficient technological operations, more reliable radioactive waste management and disposal, better security of materials and more effective international safeguards that need to be applied to plutonium separation and storage facilities. The project will cover the nuclear fuel transport, storage, processing and recycling activities, starting from the time the spent fuel leaves the nuclear power reactor through all subsequent steps until recycled fuel, in the form of fuel elements, is ready for shipment to the reactor.

As against certain strategic and economic advantages, some important questions remain unanswered on the applicability of this concept especially for developing countries. Siting of regional fuel cycle centres in any particular country will be decided on the basis of the existing and foreseeable political situation of that country as *analyzed now.* But political conditions do change, and considering the time frame of the hazardous and strategic conditions, from a long-term point of view doubts exist whether it is safe to have a plutonium inventory larger than necessary in any particular country. Another concern is in respect to the "high-level" radioactive wastes that come directly from chemical reprocessing of used nuclear fuel, and the so-called "alpha" wastes that consist mainly of equipment and materials used in the nuclear fuel cycle, that become weakly contaminated with long-lived radioactive materials, e.g., plutonium. Unless new chemical separation processes can be successfully introduced to separate the long-lived fractions and return them to the reactor itself to be "burned out", then the wastes will need safe storage for thousands of years in safe geologic structures. In any event, large amounts of these various wastes must be handled and stored in liquid form during interim processing which will probably require several years. The hazards associated with the continued handling and storage of these dangerous materials will affect decisions about nuclear power; and minimizing both the quantity and the hazard of these wastes require high priority attention.

For nations that anticipate a large expansion of nuclear power generation, the concept of a central nuclear power park has many similarities, but raises in addition the problems of siting and the general effects on social and economic planning for whole regions of a country.

Does the emergence of planning concepts based on regional centres at an international level and centred nuclear power parks at a national level contribute in any way to the safe and secure management of the nuclear fuel cycle, or are these concepts directed towards the curtailment of technological self-sufficiency of certain countries due to political and other considerations? Alternatively, are these concepts engineered by the commercial arm of the nuclear power industry in response to external criticism?

3. Current Attempts to Restrain Nuclear Power Developments

In June 1976 the people of California were asked to cast their votes on the Californian Nuclear Safeguards Act. The initiative took the following form:

- To prohibit nuclear power plant construction and prohibit operation of existing plants at more than 60% of original licensed core power level unless federal limits were removed on liability for accidents.
- After five years – to require derating of plants 10% annually unless the legislature by two-thirds vote confirmed effectiveness of safety systems and waste disposal methods.
- To permit small-scale medical or experimental nuclear reactors.
- To appropriate $800.000 for the expenses of a fifteen person advisory group and for legislative hearings.

If the proposed initiative had been adopted, this would have restricted the operation of existing nuclear power plants. In the event, the ballot showed a two-to-one majority against the adoption of the initiative; but undoubtedly this will create an important precedent in a number of other countries following the experience of both Sweden and the U.S. The cumulative effect of this process of public consultation cannot be predicted. In a number of industrialized countries, decisions on the planning of nuclear power programmes are not subject to public scrutiny but are instead regarded as strategic decisions taken "in the national interest". However it is clear that until there is a much more open public debate on the subject of large-scale nuclear energy programmes, decisions will continue to be made in the more restricted context of government agencies subject largely to economic considerations.

4. The Issue of a Moratorium

In the present situation of uncertainty about the potentialities for good or evil of nuclear energy, several countries are practicing or considering a moratorium on nuclear developments, and churches are sometimes exercising their influence on the public. A moratorium might affect all production of nuclear energy or only certain specified types (e.g., the fast breeder reactor). It might defer commercial production of energy or might extend also to experimental projects.

Obviously a moratorium is only a delay. It defers the decision to proceed with nuclear production or to stop it. Sooner or later the decision must be made. Determined advocates or opponents of nuclear energy will not favour a moratorium unless for tactical reasons.

Many who favour the moratorium put forward two substantive arguments:

(1) A moratorium may slow the momentum of a process that some think is moving too fast. The delay may give time for further public discussion, so that the public is not to be confronted with a *fait accompli.*

(2) A moratorium may give the opportunity for specific research on technical points where more information is needed for decisions.

Those who oppose the moratorium use two different arguments:

(1) A moratorium on nuclear energy, unless combined with radical social changes not now in process, increases the reliance of industrialized nations on scarce energy sources, thereby reducing the energy available to poorer countries. Since the industrialized countries can pay for such energy (e.g., by importing petroleum), the hardship falls on countries that cannot compete financially. There are some evidences that if country A reduces expectations of nuclear energy production and thereby increases its oil imports, country B feels pressure to speed up its nuclear production in the face of scarcer petroleum supplies.

(2) In the case of experimental programmes with long lead times, a moratorium, if really effective, may produce an energy crisis of a different kind at a later date.

For these reasons we think that a moratorium is not simply delay of a decision or an easy way to avoid a decision. It is itself a decision with serious social consequences.

5. Nuclear Energy and Global Social Justice

Will the spread of nuclear energy contribute to or weaken the struggle for social justice within and between nations? Some oppose nuclear energy because they believe that for the foreseeable future it is of the greatest benefit only to the rich and the already technologically developed nations. Moreover, in the name of "security" the nuclear nations tend to band together to guard the sharing out of the sensitive nuclear technologies, thus producing the secretive nuclear club, determining which nations will have access to nuclear energy and on what conditions. The sale of nuclear technology to countries with repressive social and racial policies has

further heightened the fear of many that nuclear energy will increase injustice. And many in the poorer countries are convinced that the political criteria used to determine the sharing of nuclear technologies serve only the interests of the already powerful nations.

Many also believe that sophisticated nuclear technology has unfavourable social implications, accentuating the formation of industrial-urban concentration and the centralization of technical power which many countries are trying to oppose. Nuclear energy seems thus to work against the movement for smaller scale technology and alternative and more socially appropriate energy systems.

However, to many developed and developing nations nuclear energy appears to offer freedom from dependence on other foreign energy resources and they assert their right to benefit from nuclear power development. Many are in a position (e.g. Cuba, Brazil, Jamaica) where nuclear energy could free them from dependence on expensive imports of oil or coal. It is significant for example, that at the recent U.N. Habitat Conference in Vancouver only one of the developing countries (Papua New Guinea) opposed nuclear energy.

Moreover, if it is true that society today has no viable alternative then it becomes all the more important to examine the social implications of nuclear energy and determine the social and political conditions under which it may be used. And these must also express the concerns of all nations and not just the interest of those already possessing nuclear capability.

ENERGY FOR MY NEIGHBOUR

Draft Plan and Manifesto for an Ecumenical Action Programme

Background Assumptions:

1. If the lot of developing countries is to be improved, they will need increasing energy supplies. Some of these supplies will come from fossil fuels which will be more readily available to them if the developed countries reduce their use of energy.
2. Energy conservation must become a matter of increasing priority in *all* countries, rich and poor alike. The difficulty is in channelling the resources conserved in one place to those most in need of that energy to achieve a basic minimum standard of living.
3. The strategies for energy conservation conducted by national governments are basically motivated by self-interest. They do not address the more fundamental problem associated with the transfer of resources to those in need.
4. It is suggested that a pilot scheme should be devised to provide an opportunity throughout the member churches of the World Council of Churches for the transfer of energy resources both at a community and at an individual level.
5. The pilot scheme conducted through the auspices of the W.C.C. and administered by the sub-unit on Church and Society should consist of three essential elements:
   i. A simple task of energy conservation that can be carried out by either member churches, local congregations or individual Christians;
   ii. the saving of energy units at this level to be converted directly to monetary units as the transfer system to be administered ecumenically;
   iii. use of the money for the implementation of prototype schemes for energy production incorporating the variety of new technologies required for sustainable energy production, at a community level in countries at relatively low stages of development.
6. An important element of this strategy would be the attempt to encourage the principles consistent with a just and sustainable society; and overcome traditional economic approaches to energy development resulting from the large-scale research and development programmes on new systems of energy production in the industrialized countries.
7. The campaign would embody the principles of the necessary transition to a just, participatory and sustainable society.

Action Programme

Step 1: Agreed targets for the energy conservation programme to be transmitted through the member churches of the W.C.C.:
- Define the practicable level of energy saving at the level of individual household, communal buildings, etc.;
- define the monitoring of energy saved and the corresponding transfer of monetary units.
- define the running period for the pilot experiment;
- define the collection and distribution procedure;
- define the prototype projects that currently demand finance at a community level in several developing countries (this will be an important motivating element in the whole programme).

Step 2: Devise an attractive package to communicate the nature of the scheme to member churches, local congregations and individuals.

– The specific target for energy conservation should be clearly defined at this point (ideally this should be as simple and direct as possible – e.g., a one-percent reduction in the use of electricity, monitored by the individual by meter reading, converted to monetary units and transmitted to a collection point);
– the collection point should be defined clearly in order to minimize the administrative effort (attention will be paid to the exchange control regulations, financial agreements in force for charitable monies of this kind).

Step 3: Definition of suitable small-scale energy projects on a regionally selective basis: the projects should cover more than one type of system in more than one country even during the pilot stage of the programme. Ideally, the projects should be virtually self-help situations, the equipment should be easily adaptable for large-scale multiplication and use, and the need for maintenance should be kept to a minimum. There are a number of small-scale systems that could be offered under this programme:

A. Simple wind power systems could be coupled to a mechanical water pump and water storage tank; the climatological selection of certain sites where water is stored and then pumped into irrigation schemes would need to be carefully controlled.

B. More rational use of small aforestation for fuel purposes, including the production of charcoal, might be carried out in association with a modest scale of agricultural work for rural communities.

C. Conversion of small-scale quantities of waste material, including sewage, into methane gas; this would include biogas conversion units suitable for domestic purposes and especially for cooking food.

D. Solar hot water heaters are considered to have somewhat limited application but may have application in some special circumstances such as for industrial and commercial needs.

E. In the urban situation in developing and developed countries, there is an urgent need to utilize waste material including normal domestic refuse for energy production; it is estimated that a city generating 2000 metric tons of refuse per day could produce around the equivalent of 50-60 thermal megawatts through wet anaerobic (without oxygen) digestion and the associated gas production cycle.

All the schemes presented in outline form could benefit from the new technology emerging through large research and development programmes in many developed countries, notably the U.S.A. and France.

A direct contact with this programme would be desirable from the outset of the pilot scheme.

Review Procedure

Step 4: The initial programme, which should be scheduled *for a period of 3 years commencing January 1977,* would have a strong participatory element and provide a strong binding function, particulary for the continuing study programme of the sub-unit on Church and Society, at a local community and individual level.

– Following the start of the programme, the progress of the pilot scheme should be regularly monitored by an advisory committee named by the Core Group of the sub-unit on Church and Society. (In addition, at least one specialist adviser should be appointed by the Core Group to provide a direct technical information linkage with the administrator of the scheme.)
– A decision point at the end of the first three-year cycle should enable the pilot scheme to be further consolidated or terminated according to circumstances prevailing at the time.
– Adaptation of the programme (even at the pilot stages) to take advantage of new emerging technologies would be an essential part of the evaluation procedure, e.g., there may be access to low cost, low energy housing designs which should be quickly tested and the scheme should be flexible enough to allow this to happen with the minimum of delays.

Assessment of Staff Effort

It is considered that the minimum of one-man year of effort should be available to this programme during the first three years duration. The pilot scheme must be self-financing, but phase 1 of the staff effort may require direct support.

Ideally two staff persons or affiliated consultants should be responsible for this pilot project with half of their time allocated to coordination, selection and planning procedures and the other half committed to field project activity.

This very tentative scheme would obviously need to be worked out in far greater detail, but in principal there appears to be no objection to offering this opportunity to final year graduate students of engineering or to master's degree candidates as part of their project work assignments.

SAMPLE MANIFESTO (for a Developed Country)

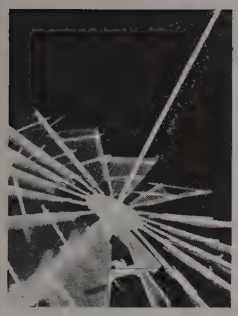
"Energy for my Neighbour"

Share your energy with neighbours around the world, at no cost. It can be done. Here is how.

Most of our developed countries use more energy and use it less well than we should. We use it in industries, shops and offices, transportation, and at home. About 25% of the world's population living in industrialized countries uses about 75% of the world's energy.

Many in developing countries require much more energy, just to survive. Some of our neighbours far away can obtain only a hundredth of what we use. A little by our standards is a lot by theirs.

Help yourself, help your neighbour. Help the world. Estimate how much energy you use. Make a plan to conserve by using less, then contribute its value through your church and the World Council of Churches. The money will go directly to energy projects in developing countries, specifically matched to their needs, such as local wind power, and better use of solar possibilities. These projects will help your far-off neighbours throughout the world to increase their strength, through your effort.



THE NUCLEAR DEBATE IN THE CHURCHES

Reactions to the W.C.C. Report on Nuclear Energy *

I. Introduction

The "Report on Nuclear Energy", prepared at the Ecumenical Hearing in Sigtuna, Sweden, June 24-29, 1975, was published in October 1975. It has evoked an unexpectedly large response and has already served a valuable purpose in many countries by stimulating the level of concern over the future implications of the growth of nuclear power.

The report, originally published in a limited edition of the bulletin *Anticipation* (No. 21, October 1975), has been in such demand that it was decided to make the document more widely available. The St Andrew Press of the Church of Scotland will shortly publish the papers and the report of the conference in a paperback entitled *Facing up to Nuclear Power.* (The Westminster Press in the U.S.A. will produce a similar paperback edition).

In the meantine French and German editions of the report have been published cooperatively by Christian study groups in France, Germany and Switzerland. A Spanish translation is in preparation in Latin America.

The material has been of particular interest to many nuclear scientists, government policy makers, industry and political leaders, as well as theologians and social ethicists, and has been generally welcomed especially in countries where the debate about the extension or introduction of nuclear energy programmes is underway. This includes Japan, New Zealand, Argentina, Brazil, Holland, the U.K., West Germany, France, Switzerland and the U.S.A.

There have been many favourable reactions to the report both from those opposed to as well as those in favour of nuclear energy. But quite apart Dr Magnus Pyke, Secretary of the British Association for the Advancement of Science, writes:

> *"The report on nuclear energy ... is absolutely first class. ... It contains a wealth of valuable material and set(s) out admirably the ethical principles underlying the whole problem."*

Writing in *The Times* (London) for December 15, 1975, and *The Observer*, Bishop Hugh Montefiore says:

> *"The public hearings held at Sigtuna in Sweden earlier this year under the auspices of the World Council of Churches (Report on Nuclear Energy,* Anticipation, *October 1975) provide a splendid example of what is urgently needed in this country (U.K.) now before decisions are made which may lead to 'inevitable' programmes."*

From New Zealand, Sir Guy Powles, Director of the Office of the Ombudsman, writes:

> *"The issue of* Anticipation *on Nuclear Energy is ... a really magnificent and most timely document ... The issue presented is one of the greatest of our time, and the thoughts and presentations put forward are of great value, particularly in countries like mine where we seem to be trembling on the edge of the nuclear brink in more ways than one."*

Dr David Rose, Professor of Nuclear Engineering at M.I.T., in a paper addressed to American legislators and energy scientists, notes "that the W.C.C. study is the best general assessment that I have yet seen" and "is of outstanding quality".

Some commentators, particularly in the U.S.A. where the nuclear energy debate is already polarized, have found the W.C.C. report "equivocal" or too "neutral". Prof. Charles West of Princeton Theological Seminary describing the nuclear controversy at Princeton University notes:

> *"The statement produced by the ecumenical hearing is known, but tends to be ignored by the pro-nuclear energy forces and vigorously opposed by the anti-group. Such is ... the fate of reason and moderation when political conflict is the name of the game."*

This last comment highlights one of the problems in relation to the discussion of nuclear energy. Nuclear energy seems to be something that people find it very easy to develop positions on – the thing at the present moment that people love to hate. It was therefore important that in entering this particular debate the World Council of Churches should try and introduce a note of fairness. At Sigtuna there

*) This Report is taken from the book *Facing up to Nuclear Power,* edited by John Francis and Paul Abrecht, published by St. Andrew Press (Scotland) and Westminster Press (U.S.A.), 1976.

was consequently a wide range of positions, including those for and against, and some people hovering around the mid-point or positions inbetween. Not only was it impossible for such a varied group to produce anything approaching a consensus statement on such a controversial subject, but the struggle to achieve such a statement would have totally denied the integrity of each individual expressed through his or her contribution to the hearing process. There was undoubtedly common ground that could be shared by the majority of the participants and this is clearly reflected in the body of the report. At the same time it must be acknowledged that there were major differences of opinion over the social responsibilities of scientists, engineers and others whose task it is to secure the nuclear fuel cycle.

The achievement of Sigtuna was to reflect fairly these divergences. It is not surprising that in the continuing public debate these differences persist and that they should be reflected in the evaluation of the ecumenical report.

II. Reactions from Churches

In several countries churches have begun to respond to the social and ethical challenge posed by nuclear energy. They also want to encourage a wide-spread public debate. The W.C.C. Report is being used as a starting point for discussion in the U.S.A., Scotland, Denmark, New Zealand, Australia and Argentina. For example, a summary of the W.C.C. Report was submitted to the Assembly of the Church of Scotland, meeting in Edinburgh in May, 1976 with a proposal in favour of "convening a hearing in this country (U.K.) on similar lines to that which took place at Sigtuna, involving scientists, technologists and theologians, in a further examination of the issues as they affect the United Kingdom, especially the question of the fast breeder reactors". (*)

In Denmark, New Zealand and Australia the churches are making plans to encourage and participate in a developing public debate about the policy of introducing nuclear energy into these countries.

In other countries where the debate about existing nuclear power policies is already underway use has been made of the Sigtuna Report, as the starting point for a new look at the social and ethical issues. This is true in Holland, Switzerland, West Germany and France. For example, in Germany a group of theologians and scientists have formulated a statement on the *Need for a Moratorium*, questioning the Federal Government's plans for increasing development of nuclear power and outlining a 9-point programme:

"1. *We demand in the first place a drastic reduction and slow-down of existing plans for nuclear power plants.*

2. We advocate intensification of research efforts into the controversial issue of risk.

3. We demand a medium-term programme of energy conservation which, besides covering energy needs would provide time and scope for the development of new energy production technologies. To avoid any misunderstanding: energy conservation through better use of the energy produced, even without any increase in the primary energy used, does not mean a halt to economic growth.

4. We consider that a reduction of the annual rate of increase of primary energy input is urgently needed.

5. We advocate an immediate increase of technological development of new sources of energy (e.g. solar energy, nuclear fusion). These projects cannot conceivably be implemented without international cooperation. We stress the importance of traditional energy sources such as coal, petroleum and natural gas for the short and middle-term energy supply in West Germany. For the long-term, neither fossil nor nuclear fuels are ideal energy production processes.

6. We underline the need to take ecological and regional planning criteria into account in the development of energy production at both national and international level. In West Germany we are in the process of destroying the ecological balance by subjecting the last remaining agricultural areas to an expansionist energy and industrial policy with serious consequences for the environment.

7. We demand a clear definition of priorities in the energy policy of West Germany, responsibly controlled by the proper democratic channels and with all due attention to energy conservation measures, protection of the environment, alternative sources of energy production and appropriate safeguards in the foreign sector of the economy.

8. We warn against one-sided and uncontrollable determination of scientific and technological policy such as has led to the choice in favour of nuclear energy. We support all measures undertaken by the Federal Government leading to greater openness in political decision-making regarding technological innovations in the energy sector. This implies, among other things, that the area between different prognoses and scientific assessments will be the subject of thorough and public discussion.

9. We criticize the mistaken and widely propagated idea of national self-sufficiency for West Germany in the matter of energy provision and stress the security safeguards inherent in international economic involvement and interpendence. The economic future of West Germany and the stability of her social conditions can only be guaranteed by international economic cooperation and a diversified energy programme. Furthermore, the possibility cannot be excluded that the uranium-supplying countries will band together to form an OPEC-type organization.

In France, a conference of theologians and scientists on nuclear energy met in Paris, May 8 and 9. The meeting pointed to the need for more public understanding of the consequences of a rapid growth of nuclear power.

In Switzerland, church bodies in several cantons have been actively opposing the Government's nuclear power policy. Most of their statements have asked for a moratorium on the further development of nuclear energy.

The W.C.C. Report on Nuclear Energy has received particular attention in the U.S.A. where its publication coincided with a statement prepared by a Committee of Inquiry on the Plutonium Economy, arranged in cooperation with the Division of Church and Society of the National Council of Churches.

The statement of the N.C.C.'s Committee of Inquiry adopted a strong position against the plutonium economy and called for a moratorium on development of a commercial breeder reactor.

This position was criticized by the nuclear power industry and many scientists. A meeting to hear the critics was organized by the N.C.C. in New York City, January 28, 1976. Later the Statement on the Plutonium Economy was withdrawn and replaced with a resolution on the Plutonium Economy asking for the "Government of the U.S. to declare a moratorium on the development of a plutonium economy

until the people of the United States can assess the pros and cons of the issues, said moratorium to be defined as follows:

> A moratorium on the commercial processing and use of plutonium as an energy source, and on the building of a demonstration plutonium breeder reactor, pending further study of the theological, economic, socio-political and technical issues involved."

This was adopted by the Governing Board of the N.C.C. at its meeting in Atlanta, Georgia, March 2-4, 1976.

In a report (March 2-4, 1976) to the Governing Board of the National Council of Churches U.S.A., the N.C.C. Division of Church and Society compares its own approach to the problems of "the Plutonium Economy" with that of the W.C.C. Hearing on the Problems of Nuclear Energy, as follows:

> *"The goal of the (NCC) Division of Church and Society was to raise the issue of plutonium use for full and wide discussion within the churches, an end which could best be accomplished by suggesting a strong position on one side or the other of the plutonium debate. In contrast, the World Council of Churches was simultaneously studying the wider field of nuclear energy, using a process of gathering opinions from people on all sides of the issue. The predictable result was a report which stated both the pro and con arguments, stressed the importance of the issue, but neither rejected nor supported nuclear energy use.*
>
> *"While we respect the World Council's choice of process, it was the Division's conviction that, since people are being asked to make decisions for or against nuclear energy today, to remain 'neutral' is in practice to support continued growth of nuclear capacity in the U.S. and increasing reliance upon it. The World Council's 'balanced' report failed to arouse debate on the issue within the U.S. Church community.*
>
> *"In any case, the N.C.C. had chosen to concentrate on the use of plutonium as a fuel, rather than on the wider use of nuclear energy, so comparison of the two processes is not very meaningful...*

The debate in the U.S. has subsequently moved forward into an even more critical phase with the vote on proposition 15 in a California initiative action which sought the approval of voters to require the nuclear industry to waive federal liability limits in order to continue operation and construction of nuclear power plants. It would also have necessitated a two-thirds vote of confidence by the state legislature within five years that nuclear safety and waste disposal systems at each plant are adequate. This was a major test of public confidence in the operational arm of the nuclear power industry and received attention throughout the industrialized world. Since the United States is probably the leading exporter of commercial scale nuclear technology, this response at the level of the decision could represent a pivotal point in the debate as far as the public acceptance of nuclear technology for electricity generation is concerned. In the event, California citizens gave a more than 2 to 1 majority vote against proposition 15 in June 1976.

III. Comments and Reactions of the Nairobi Assembly

The Fifth Assembly of the World Council of Churches meeting in Nairobi, Kenya, November/December 1975, received the Sigtuna Report on Nuclear Energy and in turn transmitted the following statements to the churches:

> **Nuclear Energy.** Increasing pressures on the world petroleum market bring the prospects of rapid expansion in the construction of nuclear power stations in countries at widely differing stages of development. This poses ethical dilemmas in view of (1) the inevitable coupling of nuclear energy for electricity generation and the production of nuclear weapons: how to limit the use of nuclear energy only for peaceful purposes of development? (2) The hazards involved in the storage of nuclear waste for long periods; and (3) the problems of theft and sabotage. The ecumenical discussion of these issues has just begun and needs to be continued. Discussion should concentrate on the effectiveness of the monitoring and control of the nuclear fuel cycle at the international level, ratification of the Non-Proliferation Treaty by all countries possessing nuclear technology, the drift towards a plutonium fuel economy and its consequences, and the political and military implications of the further spread of nuclear technology.
>
> **Alternative Energy Technologies.** During the next decade, there will be increased research and development of alternative systems of energy production. The world is now entering the transition between dependence upon petroleum to dependence upon other sources of energy, e.g. solar, wind, water and geothermal. Priority must be given to ensure that research on alternative energy sources is funded at a high level, especially as these technologies will be of direct benefit to developing countries.

These statements were then supported by the following recommendation to the churches:

> **Nuclear Energy.** As far as nuclear energy is concerned the churches at the national level should lobby for more effective safeguards in the control and operation of the nuclear fuel cycle to ensure that there is a reduced risk of diversion of strategic weapon materials; in addition there is a need to press for more serious investigation of the long-term disposal of radio-active wastes by those responsible for the management of nuclear power programmes. The churches are further urged to register their reactions to the findings of the Ecumenical Hearing on Nuclear Energy, Sigtuna, Sweden, 1975. (See "Report on Nuclear Energy", *Anticipation* No 21, W.C.C., October 1975.)
>
> **Alternative Energy Technologies.** Since there are inevitable grave ethical problems involved in the application of nuclear energy, we recommend that the churches and individual Christians seek to promote sufficient funding and moral support for research and development of renewable sources of energy, e.g. solar and wave energy.

IV. The Issue of a Moratorium

In the present situation of uncertainty concerning the further use of nuclear energy several countries are practicising or considering a moratorium on nuclear power development, and some church groups have adopted this approach. In its recent meeting the Church and Society Working Group considered the pros and cons of the moratorium strategy and concluded, "we think that a moratorium is not simply a delay of a decision or an easy way to avoid a decision. It is itself a decision with serious social consequences." Their full statement on this question will be found in the paper *Energy for a Just and Sustainable Society*, prepared by the Working Group (May 1976).

V. The "Nuclear Club" and the Management of the Nuclear Fuel Cycle

During the past year (1975-76) a group of seven nuclear exporting nations – Canada, France, Japan, U.K., U.S.A., U.S.S.R. and West Germany – has met in secret to define stringent new conditions for securing the so-called "sensitive technologies" associated with management of the nuclear fuel cycle. These sensitive technologies are (1) the enrichment of uranium, (2) the reprocessing of spent nuclear fuel (N.B. both of these processes yield fissile material from which nuclear weapons can be made) and (3) the refining of heavy water, which is a key requirement for the operation of certain types of nuclear reactor. The new terms for safeguarding exports of these three technologies were made public in a parliamentary reply by the U.K. Foreign Secretary on March 31, 1976:

- First, the exporting nation will require an assurance that nuclear technology of any description will not be used to manufacture a nuclear explosive for any purpose, including so-called peaceful nuclear explosives (PNE's) designed specifically to perform an earth-moving task. This stipulation was not made before in contracts negociated with nations which had refused to sign the Non-Proliferation Treaty (NPT).
- Secondly, the exporting nation will require an assurance that exports will be adequately safeguarded against the risk of theft or sabotage. This is an entirely novel requirement, and reflects the growing public concern with the activities of terrorists and dissident political groups.
- The third requirement concerns the re-exporting of nuclear technology transferred from one nation to another. The recipient will be required to give assurances that the technology will be re-exported only under the same international safeguards that covered the initial transfer of the technology.
- The fourth requirement covers "replication", the possibility that technology transferred from one nuclear facility under international safeguards might then be used by the recipient to construct other facilities beyond the reach of those safeguards. The supplier will require assurances that safeguards will apply to any replication of plants within 20 years.

While all seven member nations of the nuclear suppliers group agreed on the same assurances, another three nations – the Netherlands, Sweden and East Germany – have joined the group. It is expected that in addition Belgium, Italy and Czechoslovakia will also comply. With these negotiations still in the very early stages, it is clear that the present agreement cannot be considered as the ultimate in safeguards. The United States, in particular, is still pursuing its suggestion of regional fuel cycle plants operated under international control to prevent misuse of the plutonium by-product.

VI. The IAEA Sponsored International Conference on Nuclear Power and its Fuel Cycle

In May 1977, the International Atomic Energy Agency will sponsor an international conference on *Nuclear Power and its fuel Cycle.* One of the topics is "Public Acceptance of Nuclear Energy", and the World Council of Churches has asked for the privilege of presenting its views on this subject.

There is a wide-spread agreement in the churches that more information is needed by the public on the implications and problems of the continued expansion of nuclear energy and that the choices involved should be exposed to wider public discussion. There is also a growing awareness in the churches that the debate about the ethical and religious implications of nuclear energy requires urgent attention.

VII. Nuclear Energy and Global Social Justice

One of the controversial questions in the discussions of nuclear energy is whether it contributes to or weakens the struggle for social justice. Many of the campaigns against nuclear energy hinge on the argument that nuclear energy works against social justice – because of its link with the proliferation of nuclear weapons; because it strengthens the power of the technologically developed countries; and because the present system of sharing out nuclear technology favours the rich and the powerful nations over against the poor. It is moreover a technology which supports the continued growth of large urban concentration.

The counter argument is that as conventional energy sources become more costly or, for various reasons, less desirable, new energy systems must be developed. And even if there should be a concern to limit energy growth for the developed countries in the future, the developing countries will need larger supplies of energy for many decades to come. In the search for such supplies nuclear energy must be regarded as a valid option. As the report on Energy for a Just and Sustainable Society points out, "at the recent U.N. Habitat Conference in Vancouver, only one of the developing countries (Papua New Guinea) opposed nuclear energy". And the socialist countries like Yugoslavia, Czechoslovakia, Romania and the U.S.S.R. are convinced that they have no other solution than the development of nuclear energy to replace diminishing traditional energy sources.

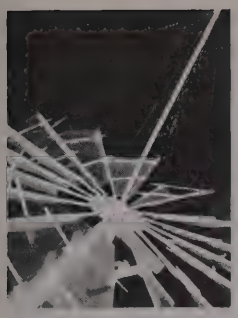
Conclusion

Nuclear Energy, as no other issue, highlights the uncertainties underlying the future of scientifically and technologically organized societies. The churches have much to do to inform themselves on the options involved and the ethical and social implications in making a responsible choice. The Working Committee of Church and Society has therefore urged the W.C.C. to continue its efforts to evaluate the role of nuclear power and widen the discussion with the churches and with the pertinent scientific and governmental and inter-governmental bodies making policy on this issue.

A Warning from the International Energy Agency (IEA)

"The future of energy conservation in the IEA is, at best, uncertain... One particularly disturbing fact, for example, is that some IEA Members continue to price energy below world market levels. This can result in diminished future investments in energy efficiency and less attention by energy consumers to the wise use of energy. In most IEA countries the populace is sceptical that any energy problem exists. It remains to be seen whether in such an environment Member country governments put into effect policies and programmes pending, or develop and implement new approaches to conserving energy over the next 10 to 15 years."

From *Energy Conservation in the International Energy Agency: 1976 Review,* published by the Organization for Economic Cooperation and Development (OECD), Paris, September, 1976; p. 8-9.
(19 countries participate in the IEA: Austria, Belgium, Canada, Denmark, Germany, Greece, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, Turkey, the U.K. and the USA.)



NUCLEAR POWER AND PUBLIC POLICY

(The following is the concluding chapter from the Report on Nuclear Power and the Environment, *published by the Royal Commission on Environmental Pollution (U.K.), September 1976.)*

Introduction

In previous chapters we have considered the environmental implications of nuclear power, both actual and potential. We now draw the various considerations together in discussing the future of nuclear power and in giving our views on the policy that should be adopted towards its development. As we said at the start of this Report, we are conscious in doing so of touching on matters that are at the fringe of, if not beyond, our strict terms of reference as a Commission concerned with environmental pollution. This appeared to us to be unavoidable, however, if we were to present a complete account, and to provide a foundation for the wider discussion of these issues that we believe to be essential.

It is important that the discussion should be well-informed and as far as possible dispassionate. It seems that nuclear power has in some ways become the whipping-boy for technological development as a whole. Many thoughtful people believe there is a progressive deterioration of the environment which they associate with the spread of technology (we have in mind here not pollution alone, in which there have been many local improvements, but the total impact on society) but feel unable to make a stand against this process because each individual step is small and can probably be justified as bringing benefits at minimal environmental costs. Nuclear power provides a dramatic focus for opposition in some countries to technological development and we have no doubt that some who attack it are primarily motivated by antipathy to the basic nature of industrial society, and see in nuclear power an opportunity to attack that society where it seems likely to be most vulnerable, in energy supply. In the USA in particular we see a situation in which the debate between the nuclear industry and the environmental movement has become increasingly vociferous. The environmentalist tends to see those in the industry as being so committed to furtherance of their technology as to be wilfully blind to its dangers to the world. Those within the industry, many no doubt sustained by the thought that they are thereby making an essential contribution to the well-being of mankind, tend to see environmentalists as people opposed to all technology who are prepared to denigrate their work on the basis of drummed-up and nebulous fears of future catastrophes. During our study we have had many contacts with the various sides of the nuclear industry in this country and with its environmental critics. The arguments of both deserve to be heard with greater mutual understanding.

We are acutely aware that concern about the large-scale use of nuclear power, and the concomitant threat of plutonium in a civilian context, may appear misplaced in relation to what many would see as a much greater threat, that growing arsenals of nuclear weapons may one day lead to nuclear war. The implications of civil nuclear development are qualitatively different, however, and are not to be seen as a mere increment in the nuclear threat. The connection between civil and military uses of nuclear power is obvious; there is the possibility that great expansion of civil use would make more difficult the eventual acceptance and introduction of measures to secure nuclear disarmanent.

We begin our discussion on the future of nuclear power by recapitulating the main hazards of its development and the salient features of future energy supply.

The Hazards of Nuclear Power Development

There is first the question of reactor safety. We have seen that the consequences of a large release of radioactivity could be extremely serious, and concern on this point is not entirely assuaged by the fact that other technologies may present comparable, or even greater, hazards. We are confident that the risk of accident leading to a serious release of radioactivity is at present very small, having in mind both the existing scale of nuclear provision and the attention devoted to safety in reactor design and operation. The risk will certainly increase with the number of installations, however, and a rigorous commitment to safety must be maintained. There is the question whether this commitment might become dulled; it is a common enough experience in other fields that familiarity, and continuing success in an enterprise, lead to failures in preserving standards and adequate organisation. The Flixborough disaster supplies an example of this. There is the question of the potentially greater hazards of the fast reactor (paragraphs 297-304) and whether, in our anxiety to grasp the benefits it offers, we may be tempted to accept a qualitatively different increment in risk. There can be little doubt that as the number of reactors in use throughout the world increases, there will in time be a major accident. Such an accident, even if it occurred abroad, would certainly cause anxiety in this and other countries and might require reactors to be shut-down while safety aspects were reassessed. This alone suggests that it would be prudent to aim for diversity in energy supplies.

The risk of a serious release of radioactivity from a reactor or other nuclear installations would be substantially increased by act of war or sabotage. Nuclear installations could well be prime targets in time of war. A policy of concentrating nuclear facilities on one site, such as might be adopted to reduce the problems of safeguarding dangerous nuclear materials which would otherwise have to be transported from one facility to another, would make the site more vulnerable and more attractive to attack. There is here a difficult question of balance.

We have described in Chapter VIII the problems associated with the management and disposal of highly radioactive wastes arising from the nuclear fuel cycle. Such

wastes will remain active over immense time scales, and unless continuously isolated will present dangers to our remote descendants long after nuclear fission technology has ceased to be used as a source of energy. We believe that a quite inadequate effort has been devoted to the problems of long-term waste management, and that there should be no substantial expansion of nuclear power until the feasibility of a method of safe disposal of high level wastes for the indefinite future has been established beyond reasonable doubt. There are promising ideas for the disposal of these wastes but it may take 10 to 20 years to establish their feasibility.

Lastly, there is the problem, discussed in Chapter VII, that is in many ways the most worrying and the most difficult to assess, that is, the risks arising from the production and use of plutonium in large quantities, which would follow from the widespread introduction of fast breeder reactors. This proliferation would make it easier for terrorist or criminal groups to obtain the element and use it in acts against society. Knowledge of plutonium and the ability to use it for nefarious purposes will inevitably be disseminated as nuclear power spreads. There is no lack of demonstration in the world at present of the audacity, determination and ruthlessness of terrorist organisations. Unless we are prepared to assume that terrorism is no more than a transient phenomenon, or that terrorist groups would shrink from using the immense threat of plutonium to achieve their ends, then the future risk of such action exists and must be considered.

Another aspect of the problem is the possible effect of such threats on society. The security measures that might become necessary to protect society could seriously affect personal liberties. The need for such measures would be affected by increasing tensions between nations. Indeed, the future risks posed by plutonium constitute a world problem that would not be solved by unilateral action by the UK, though the action we take in response to our assessment of these risks could have a substantial impact on world opinion. We emphasise again that our concern here is not with the position at present, or even in the next decade, but with what it might become within the next fifty years. In speculating on developments on such a time scale no one has a prerogative of vision. It appears to us, however, that the dangers of the creation of plutonium in large quantities in conditions of increasing world unrest are genuine and serious.

We have given some thought to whether the present organisational arrangements are conducive to achieving an appropriate balance in the use of resources for energy research and development in the different fields. In this context we have noted the conversion of the former AEC in the USA into the Energy Research and Development Administration whose annual budget covers support for both nuclear and non-nuclear energy projects and which we believe has led to larger and better co-ordinated projects in the non-nuclear field. We do not suggest that an identical body would be appropriate in the UK where the structure of organisations involved in energy matters is very different. In the USA, for example, the coal industry is fragmented, in contrast to the position in this country where research and development in this area is conducted by the National Coal Board. However, we see advantage in extending the remit of the AEA so that it would become responsible for energy research and development in a wider field. We have in mind that the Authority would assume responsibility for work on renewable energy sources. We would expect much of this work to be done under contract from the Authority to research groups in universities and other establishments, the programme being controlled and co-ordinated by the AEA. The AEA would need to build up relevant expertise and we foresee that, at a later stage in development, some of its present scientific and technical resources would be diverted to work in these other fields. We recommend that the Government should consider this extension of the AEA's functions and correspondingly of its title.

In the end the allocation of resources for energy development must depend on energy policy. We are conscious of the immensely difficult issues involved in framing a coherent policy and we greatly welcome the initiative of the Secretary of State for Energy in promoting wide public debate on this subject. In that debate and elsewhere it has been suggested that there is a need for a high-level independent body to provide advice on energy strategy, taking account of economic, social, technical and environmental considerations. We strongly support this idea. Our study of nuclear power has made us deeply aware of the need for authoritative exposition of the implications of different policies that might be adopted on energy supply. It is our particular concern that the environmental consequences of alternative strategies should be comprehensively explored and assessed, but this is only one aspect and the implications must be looked at as a whole. We do not think that this can be done adequately by existing machinery and by collective action of the government departments involved. There is a need for freedom and originality of thought, and for independence from institutional pressures and from the need to justify existing arrangements and policies. It should be the principal aim of the advisory body to promote public understanding of the full implications of alternative energy strategies and to promote development of the consensus which is needed to guide the Government in framing its policies. We see a specific role for such a body in relation to proposals we make in paragraphs 523 and 524 regarding the future development of nuclear power.

FBR Development

We have explained that we accept the need to maintain a nuclear option; our concern is that UK planning might depend too much on the introduction of FBRs on a substantial scale and a move into the plutonium economy. There is of course no present commitment to an FBR programme. The next major step in their development in this country and others is the design and construction of a first commercial scale fast reactor, the CFR1, which is needed in order to establish, among other things, whether the safety problems can be adequately resolved for commercial exploitation to be feasible. This development could well take a decade or more, and if it is accepted that the country may need FBRs in operation by about the turn of the century it is not too soon to start.

As a Commission concerned with environmental pollution it is not for us to propose that CFR1 should go ahead. Nor do we oppose the development of CFR1 itself on environmental grounds. Nevertheless, although it is a very long way from building CFR1 to a plutonium economy, we must view this highly significant first step with misgivings. The cost and momentum of technological development on this scale are such as to make one fear that it will lead inevitably to a large FBR programme in the future. There is a considerable risk that inadequate resources will be available for the development of alternative energy programmes, including conservation, which might have made substantial future dependence on fission power unnecessary.

The strategy that we should prefer to see adopted, purely on environmental grounds, is to delay the development of CFR1. This would provide time for the socio-political aspects of the plutonium economy to be fully investigated and debated, so that the risks could be widely understood and judged before this first step was taken. It

would free resources and provide a stimulus for work on alternatives. It would give time for the problems of waste management and disposal to be properly investigated and, we hope, resolved. Each year of delay would increase the prospect of establishing whether a viable alternative strategy existed which would avoid the need for FBRs.

We recognise, however, that such a delay might well create very serious problems which are not within our remit for investigation. The prospect of indefinite postponement of a crucial stage in fast reactor development would inevitably result in the loss of expert technologists from the industry and weaken the sense of purpose which is essential to the enterprise. It might, therefore, seriously damage the prospects of eventual success. There is the possibility that delay might lose us opportunities for collaboration with other countries which could reduce the cost of the development. There is the risk (notwithstanding our doubts about the future necessity for nuclear power on the scale of official projections) that the FBR will prove to be essential for vital energy supplies and that it will not be available in time. These are matters for the Government to consider in reaching a decision on CFR1.

We hope that in reaching that decision the Government will take account of our views as expressed in this Report, and particularly of the following:

(i) It should be an aim of present policy to seek to lessen the possible future need for dependence on FBRs. Accordingly, the programme of research on other energy sources should be reappraised and should be pursued with more urgency than is now apparent and with a substantial increase in resources.

(ii) A small proportion of the resources that would be required for CFR1 could have a major impact if applied in other areas. Considerable savings might result if CFR development were pursued in collaboration with other nations, and if consideration was given to possibilities for phasing the project in ways that would not seriously affect its momentum.

(iii) If CFR1 development proceeds, it should be seen as being in the nature of an insurance policy, albeit an expensive one, justified by the importance of risks relating to the security of the nation's future energy supplies. It should be clear that the development implies no judgment on the inevitability or acceptability of a future FBR programme. These are matters which should be assessed by the procedure we describe below, and we would wish to see a commitment by the Government to this procedure before a decision to proceed with CFR1 was taken.

For this reason we think it remarkable that none of the official documents we have seen during our study convey any unease on this score. The management and safeguarding of plutonium are regarded as just another problem arising from nuclear development, and as one which can certainly be solved given suitable control arrangements. Nowhere is there any suggestion of apprehension about the possible long-term dangers to the fabric and freedom of our society. Our consideration of these matters, however, has led us to the view that we should not rely for energy supply on a process that produces such a hazardous substance as plutonium unless there is no reasonable alternative.

We have considered whether this country should seek to abandon nuclear fission altogether, but even if it could be confidently supposed that this could be done without risk of unacceptable restrictions on energy supply in the future, we should not think that such a strategy was wise or justified. We do not think the possibility that the nation would prefer to accept some risk in order to avoid what might be seen as the greater risk of a much expanded nuclear future.

We do not think that continued operation of the existing Magnox reactors, or the eventual operation of the thermal reactors that are now being installed or considered, can be thought to constitue an unacceptable hazard when judged against the benefits, provided that existing standards are maintained, as we have every reason to believe they will be. The risks we have described exist but they must be balanced against the desirability of diversity in sources of electricity. There are already substantial quantities of radioactive waste requiring secure disposal, but we are sufficiently hopeful that an acceptable solution will be found to this problem that we do not advocate halting the processes giving rise to the waste. Indeed, to do so might remove the sense of urgency that we believe to be required in seeking a solution. Finally, if as we hope fusion power is eventually developed, it will require the technical expertise and experience obtained through fission technology for its successful introduction and operation. The abandonment of fission power would certainly not advance the advent of fusion and would probably delay it.

Aspects of Future Energy Supply

Assessment of whether or not there are reasonable alternatives to dependence on fission power in the future leads to consideration of energy forecasts. In the previous chapter we described the programme of nuclear expansion envisaged by the Department of Energy and the AEA. Their estimates indicate a widening gap between energy demand in the future and the contribution that can be expected from fossil fuels. In their view nuclear power was the only proved technology that could fill this gap. Even allowing for the development of other sources of energy and the effects these might have on the scale of nuclear provision, the Department considered that a substantial fission programme would be needed; and that because of uncertainties about the future availability of uranium supplies it was essential to keep open the option of using FBRs, and hence to proceed with their development.

We accept the need to retain a nuclear option but, as we explained in Chapter IX, we are concerned about the projected nuclear expansion not only because of the specifically nuclear risks involved but on general environmental grounds. We felt bound to seek some understanding of whether such expansion was inevitable or whether alternative strategies might be available for meeting future energy needs. Our consideration of this matter has been necessarily limited and tentative, and we cannot be sure that approach we have outlined would be feasible. We fully realise that factors we have been unable to consider may crucially affect the issue. One factor of this kind, which is environmental in nature, is the build-up of carbon dioxide in the atmosphere from the combustion of fossil fuels. We referred to this problem in paragraph 192; it could yet provide a powerful argument for nuclear development. We regard the strategy we have described as doing no more than suggest that the case for a nuclear programme involving the installation of many FBRs is not yet proven. Whatever the merits of this strategy it is important that alternatives should be considered and this has been recognised by the Department of Energy which is now looking at a wide range of energy options. Even if an alternative strategy could not give the same assurance that future energy demand could be satisfied, there is the possibility that the nation would prefer to accept some risk in order to avoid what might be seen as the greater risk of a much expanded nuclear future.

Clearly in the long run other sources of energy will need to be developed, some now probably unsuspected. We have referred to one of these, namely nuclear fusion. Compared with fission, fusion would involve much less hazard from radiation. Fusion power has its critics; *) it is likely to be very capital intensive and to become available only in very large units applicable only to the centralised generation of electricity. We mention here that we attach importance to the possibility of developing fusion reactors of moderate size which would be suitable for district heating purposes. To this end we think that the possibilities of laser fusion should be explored. Our basic concern is that a major commitment to fission power and the plutonium economy should be postponed as long as possible, in the hope that it might be avoided altogether, by gaining the maximum time for the development of alternative approaches which will not involve its grave potential implications for mankind.

It may well be said that our concern on these points is premature; that there is, after all, no firm commitment to nuclear provision on the scale indicated in the AEA projections, and that other energy sources and ways of using energy more efficiently are already being actively examined. We should not be satisfied with this response. The important thing is the attitude towards alternative approaches and the resources devoted to assessing their potential and promoting their development. The basic belief of the Department of Energy and the AEA is that nuclear fission using the fast breeder reactor is the only real option for meeting our future energy needs. We fear that on this premise there may be a gradual, step by step progression to overriding dependence on nuclear power through tacit acceptance fo its inevitability, and a gradual foreclosing of other options that might have been available had they been exercised in time. We recommend that it should be an aim of policy to lessen our future dependence on fission power to the extent that this would command public acceptance in the light of a full understanding of the implications and of the issues involved. We return to this point in paragraph 521.

In our view such a policy would certainly call for increased support for the development of alternative approaches and energy sources. A programme of research on wave power was recently announced which will cost about £1 million over two years. A sum of less than £0·5 million per year is currently being spent on other sources, including solar energy.* In contrast, annual expenditure by the AEA on nuclear fission research and development amounts to about £80 million at present. The proportional expenditure on alternative sources is substantially smaller in the UK than in most other industrialised countries. The Department of Energy are examining, we think rather belatedly, the possibilities afforded by combined heat and power systems which are already in substantial use in some other countries. We think that increased resources need to be devoted to energy conservation. The Department have established the Advisory Council on Energy Conservation and we greatly welcome this, for we are not convinced that conservation has been pursuedwith sufficient vigour. Among the alternative sources we include fusion, and we are agreed that on environmental grounds, there should be substantially more effort directed to the development of fusion power. The UK is currently spending much less on fusion development than some other comparable developed countries such as West Germany and Japan.

Public Assessment of Nuclear Power

We have explained our reasons for thinking that nuclear development raises long-term issues of unusual range and difficulty which are political and ethical, as well as technical, in character. We regard the future implications of a plutonium economy as so serious that we should not wish to become committed to this course unless it is clear that the issues have been fully appreciated and weighed; in view of their nature we believe this can be assured only in the light of wide public understanding. We are perfectly clear that there has so far been very little official consideration of these matters. The view that was expressed by the Department of Energy in their evidence to us was that there were reasonable prospects that the safety and environmental problems posed by nuclear power could be satisfactorily overcome and that, if this proved not to be so, other forms of energy would have to be used, or consumption somehow reduced. We see this as a policy that could lead to recognition of the dangers when it would be too late to avoid them. More is needed here than bland, unsubstantiated official assurance that the environmental impact of nuclear power has been fully taken into account.

The question arises of how the necessary public understanding is to be brought about. Considered judgment requires the weighing of many factors; estimates of future energy needs in relation to projections of economic growth, and the environmental consequences of different energy strategies and their estimated economic and social costs. There is a need, we believe, openly and deliberately to weigh the risks and costs of embarking on a major nuclear programme against those of not doing so.

We have concluded that a special procedure is needed. This should follow, in general principles, that accepted for environmental impact statements now required for certain major projects in the USA. A comprehensive document setting out the issues and the evidence should be published first in draft. We envisage that much of the evidence would be prepared by the proponents of nuclear development, the AEA, but plainly other contributions would be required. The statement must not be confined to the effects of the first stage of development, but must follow through to the furthest point to which our current knowledge can attain. The social and economic as well as the scientific, technological and environmental problems must be fully set out.

This publication should be followed by a further stage in which the comments made by interested agencies and individuals should be presented and evaluated. These presentations should ultimately receive independent assessment and we think that this would be an entirely appropriate function for the advisory body we have referred to in paragraph 515. No doubt the introduction of such a procedure would present many difficulties which we have been unable to examine closely, but we are convinced about the need for it. The ultimate aim is clear; it is to enable decisions on major questions of nuclear development to take place by explicit political process. The discussion of the possible invironmental consequences of nuclear development which we offer in this Report will, we hope, contribute to this process but it cannot complete it.

NUCLEAR ENERGY: ITS ROLE IN HUMAN AFFAIRS

By V. Lawrence Parsegian

The most revolutionary changes for the improvement of societal life became possible when the energies contained in coal, oil, and natural gas, were made to serve human needs and appetites. Invention breeds invention, with the result that societal demands for energy spiralled to astronomical magnitudes. The effects have not been uniform around the world, however. For while in "developed" Western Europe the yearly per capita energy consumption in 1972 was the equivalent of 4.000 kg of coal (and nearly three times that in the United States and Canada) the consumption in most of the rest of the world (the "developing" societies) was one-tenth that or much less. While happiness and human progress are not determined by magnitudes of energy consumption, extreme energy disparities usually characterize unacceptable living and health conditions.

More recently the energy spiral suffered a jolt from realization of the availability and constraints affecting the oil and natural gas resources of the world. This coincided with an awakening to the serious damage to the environment caused by prodigal energy production and utilization. Thus while coal remains in substantial supply, the fear of high cost in human lives and in damage to the environment discourages too great dependence on that energy option.

The effect has been to direct attention to energy alternatives that are of the "renewable" category, and also less harmful to the environment and to human health. These include solar radiation, geothermal gradients, the energies of winds, waves, tides, ocean currents and of biological materials. But the technologies for use of these resources have yet to be developed either to meet the needs of communities or of industrial centres. What seems to emerge is that hereafter energy will not be as cheaply derived as it has been through combustion of hydrocarbons piped from the ground. Clearly we have entered a new phase in the economics of energy utilization, a phase in which industrial, agricultural, and military interests, national prestige, environmental husbandry, human progress, human suffering, moral issues, and the interests of generations yet unborn, vie for consideration.

It is within this framework that the role of nuclear energy demands special consideration. Currently nearly 200 nuclear power plants feed into the electric grid systems of a score of nations. Many people see the eventual level of world industrialization and transportation to be determined by the availability of nuclear energy.

There persist, nevertheless, reservations on the role to be assigned to the nuclear option. They derive from ethical and moral concerns involving radiation and toxicity hazards, the most serious appearing to be plutonium, and from the possibilities for transforming nuclear fuels into bombs. The inherent safety of nuclear power systems is being debated, the associated fuel processing and radioactive fission product disposal techniques have yet to be reduced to accepted commercial practice. The breeder reactor, on which the long range value of the nuclear option depends, is still only in developmental stage.

Against these reservations there rise two realities. The first is that the availability of adequate energy is critical both for the developed societies and for the large populations that suffer mass poverty and hunger around the world. The second is that greater nuclear hazards are already rampant and increasing in the form of fissionable materials and nuclear bombs. The need to effect more equitable sharing of the earth's energy and materials resources comes at a time when these resources are shrinking, and failure to develop and exploit the nuclear option *with reason and care* could invite greater human tragedies.

Nuclear Energy Characteristics

In the minds of many people nuclear energy continues to carry stigma from having come into the world as a weapon of unimaginable destructiveness. The thousands of nuclear bombs that are poised and ready to destroy body and soul of everything that we call civilized are bereft of moral content. Against this fearful background it has been possible to work out more constructive uses for nuclear energy. Nuclear systems designs permit many variations. The majority of those in current use utilize uranium oxide fuel elements in which the uranium-235 isotope (the isotope that readily fissions into smaller radioactive atoms, with release of energy) is enriched to higher concentrations than is found in nature. The plants usually require coolant water drawn from lakes or rivers to condense the exhaust steam and permit steam flow through the turbines. Unfortunately in every generating system, whether nuclear or fossil fuel, more than half of the heat energy is sent with the returning water to become "thermal pollution" in the lake or river. Technology has yet to improve on this waste for either nuclear or fossil systems.

Because nuclear systems operate many months with each fuel loading, their fuel transportation costs are modest in comparison with the needs of fossil fuel plants. With this advantage they can provide energy for outlying or undeveloped regions where distances and climate pose severe obstacles. Against this advantage, nuclear systems require a high degree of scientific and industrial sophistication to design, fabricate, construct and operate safely and efficiently.

Nuclear plants do not spew vast quantities of particulates and chemicals to pollute the atmosphere such as characterize the combustion of hydrocarbons. They are, however, sources of very intense ionizing radiation and of radioactive atoms, including plutonium. Therefore, while nuclear power plants are not capable of explosion to resemble nuclear bombs, they are not beyond human and mechanical failures. The merits of heavy dependence on nuclear energy therefore rest on the assurance that the dependence will not add to the damage and losses that are already suffered from mining accidents, refineries, transportation, and through lung and cancer damage associated

with mining and with pollution. Indeed the goal should be to seek, with proper development of the nuclear option, a lessening of the great human and environmental losses that characterize non-nuclear processes.

In a properly designed nuclear power plant the radiation and radioactive atom intensities discharged to the environment are of much lower level than those that accompany natural radiation coming from outer space and from earth materials, to which we are all subject. This can change if the physical integrity of the plant suffers such damage as to release radioactive materials to the environment. The periodic replacement of highly radioactive spent fuel elements brings into play a series of processes involving temporary storage, transportation, chemical separation, recovery of uranium and plutonium for re-use, and ultimate disposal of the fission products. While each step can be reduced to safe and routine operation, the series has yet to become clearly defined and reduced to acceptable practice.

High toxicity, long-lived radioactivity, and suitability for bomb use make plutonium of special concern should it fall into unfriendly hands. Its significance increases as the development of breeder reactors makes plutonium the more common fuel element. The hazards are real enough, but there is little to suggest that they are beyond control, or that they are disproportionately large either in relation to non-nuclear hazards or to values to be derived from nuclear energy. The fact is that plutonium has been processed, stored, and used in large quantities since 1945 without serious accident.

Indeed a necessary task has to do with developing perspective on nuclear risks within the framework of hazards from chemicals, food additives, pesticides, drugs, x-ray treatments, pollution, refining of foods, transportation, diseases, overindulgence, undernourishment, poverty, human greed, crime, vandalism, wars, and nuclear bombs, that have become so much a part of human life and death.

The total of nuclear power experience to date represents some thousands of reactor years of safe and generally satisfactory performance. It is difficult, nevertheless, to regard nuclear technology as having matured so long as there remain uncertainties with respect to fuel supplies, fuel enrichment, construction costs, inherent safety, freedom from human errors, fuel reprocessing, fission product disposal. There remain questions on the role of private entreprise, and more serious questions on the role of governments in cooperation with one another.

There remains also the overriding fact that breeder reactors have yet to be developed and assessed as to their safety, efficiency, and costs. Without breeders even the currently operating reactors may be short of fissionable fuel before the end of their useful life. The reason is that while the uranium and thorium resources of the world are extensive and capable of providing energy for some centuries to come, to be useful the uranium must be converted to plutonium and the thorium to an isotope of uranium. The conversion is called "breeding" and takes place within the power breeder reactors. Along with the breeders there comes the task of determining how plutonium will be utilized, reprocessed, and re-used without undue risk from its toxicity and availability for bomb use.

Looking farther ahead, the current nuclear experience can contribute toward the coming of fusion reactors, in which the fusion of light atoms produces energy without also producing fission products.

If fusion power systems can be achieved the world may be assured energy resources of indefinitely large dimensions. But since we do not yet have any idea of the engineering, construction, and operational features of such reactors, it is premature to identify them as being either safe or "clean".

What Posture Toward Nuclear Energy ?

Although the energy issue has become of common concern around the world, there are large differences in the reasons for concern. For very many millions the emphasis is on food to sustain the body, and for fertilizers and machinery to make agriculture more productive. For industrialized societies the goal is to find substitutes for oil energy with which to maintain economic growth.

Since nuclear energy systems are both technology-intensive and capital-intensive, they lie outside the purview of most developing societies. There is great danger therefore that nuclear energy may be reduced to the role of supporting spiralling economies that are themselves of dubious merit. The plans of developed nations to build hundreds of power reactors by the year 2000 seems to be guided by this intent. The illogic of crash action is especially evident in view of the "immaturity" aspects of nuclear development. But this does *not* suggest a *"nuclear moratorium"* as the answer. If the nuclear option is to have some future role, total cessation of construction of new plants risks serious loss of the training and experience that is needed for the development of nuclear systems. The move toward assessing the full merits and limitations of the nuclear option, as safe and useful servant of mankind, can brook neither crash construction programmes nor moratorium delays.

An urgent need of the moment is for the analysis of the role that energy (and not just nuclear energy) is to have in societal life. However successful the search for new energy sources may be, there is not likely to be room for waste either of energy or of the products that require energy to produce. For example, even in northern climates the energy of sunlight can be used to heat a home, when that residence is insulated to make it other than an "energy sieve". By the same token, the burden and risks that go with all energy alternatives can be greatly reduced if through conservation, and redefinition of societal goals, the total energy demand were substantially reduced. In the presence of hunger, deterioration of the environment, limitations in earth resources, increasing populations, and with many more generations yet to come, the issue of waste, conservation, and of more equitable distribution of energy and of goods, commands priority on both moral and "practical" grounds affecting world peace. With conservation, and through redirection of societal goals to make national progress less geared to spiralling economies, there will emerge better perspectives on the specific (and limited) role to be assigned to nuclear energy.

What about the nuclear hazards ? To begin with, the dangers of nuclear war and of surreptitious use of U-235 and plutonium have been with us for three decades, and we must learn to live with them. Of course nuclear power plants involve many more people and communities and there will be incidents of misbehaviour of the systems. Experiences to date confirm two points: first, even with the current immature nuclear plant designs the nuclear accidents have not caused damage to compare with losses suffered from many non-nuclear causes. Secondly, the dependability and safety of the systems can be improved.

Conclusions

These considerations suggest the following conclusions:

1. While the exploitation of fossil fuel for production of energy has brought social benefits to many people, we currently face the condition that

a) large segments of the world's populations have yet to share in these benefits;

b) prodigal use and misuse of fossil and of other earth resources have multiplied hazards that currently extract heavy toll in human lives and in damage to the environment;

c) the resources are shrinking at a time when demand for them continues to increase world-wide, making it necessary to look for alternative energy resources.

2. The search for energy alternatives requires parallel effort to identify more conservative and more meaningful relationships than we now have between energy and materials utilization, societal goals, and human progress. By the same token, there will be needed clearer identification of the benefits to be realized, versus the hazards and costs, associated with each alternative resource.

3. The utilization of nuclear fission processes for producing electrical energy represents one of the major alternatives. But while nuclear plants have functioned with considerable efficiency and safety, their larger future role depends on

a) improving their inherent safety, and rendering the systems less subject to human errors;

b) developing breeder reactor systems through which to exploit available uranium and thorium resources;

c) developing and reducing to acceptable practice the management and disposal of fissionable fuels and radioactive materials.

4. The hazards represented by increased nuclear power production add to those which are already widely entrenched in the nuclear bomb arsenals and commercial-industrial operations of many nations. In view of the enormous threats and possible benefits these represent, of moral and biological consequence to society, the burden for their control and utilization must be shared by ethical and religious organizations as well as by governments. The responsibility extends especially to the control of weaponry as of first priority.

5. Since nuclear energy systems are highly technological in nature and expensive to build, particular care is needed to assure that:

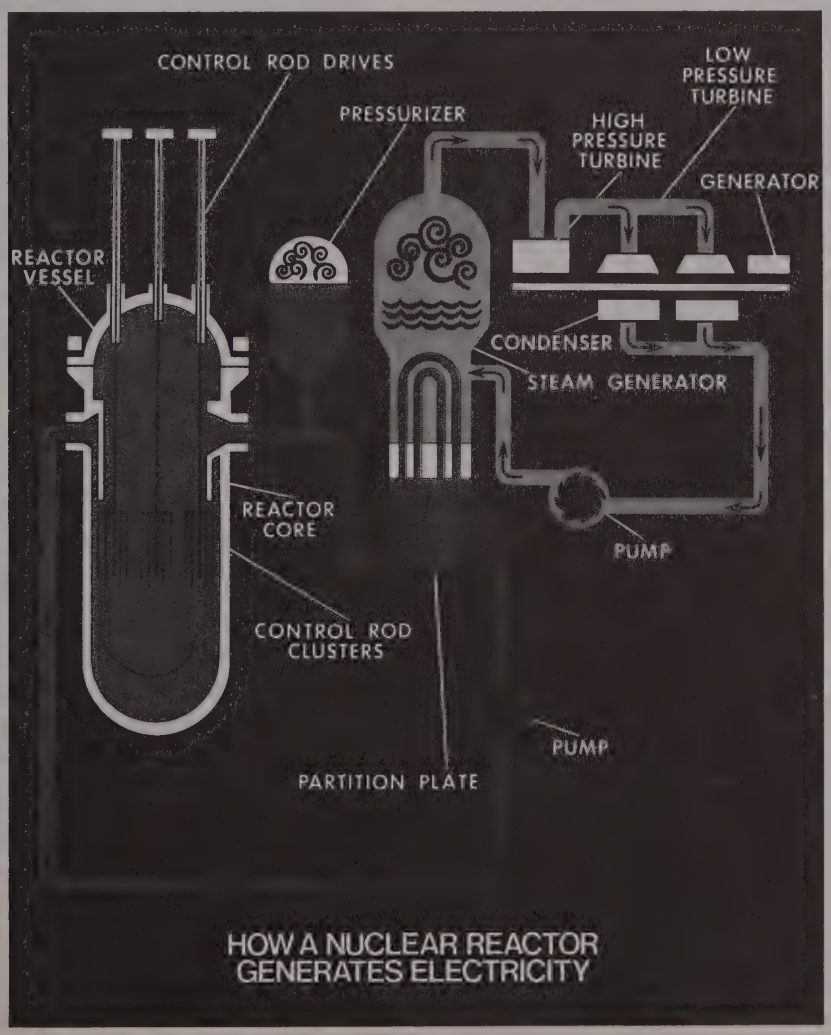
a) the benefits to be derived from nuclear energy are not denied to developing societies;

b) nuclear energy is not expanded in industrialized nations beyond need, for the purpose of supporting spiralling economies to their own ultimate hurt.

6. In view of the critical importance of energy resources for both developed and developing societies, and of uncertainties on the availability of energy alternatives, the World Council of Churches should favour continued development of the nuclear option providing the assurances noted in (3) above. This, in relation to the goals to be defined by (2) above, can define more clearly the conditions and the safe degree of dependence, that apply to the nuclear option. By the same token, too rapid addition of nuclear power plants beyond that needed to acquire experience is likely to invite unacceptable hazards.

7. The diversity of skills, materials, and land areas, that are required for support of nuclear energy systems can be made the basis for increased international cooperation, to the advantage of both the developed and developing nations.

8. The issues surrounding energy and material needs of society emphasize the importance of husbanding of earth and environmental resources as a common duty, to be shared by ethical and religious organizations as well as by governments



HOW A NUCLEAR REACTOR GENERATES ELECTRICITY

THE FALLIBILITY FACTOR*

By Garrett Hardin

For more than two decades we have struggled with the question, "Is atomic energy safe ?" Every year the proponents say it is. Then doubters point to a near-disaster, the possibility of which had not been foreseen. Following this, safeguards against that particular accident are engineered into the system and the proponents say, "See ? It's safe now ! " and the dance goes on. The dialectic sounds like a broken record.

The Rasmussen report, which cost two million dollars, should have put an end to the bickering. Two million dollars is a lot of money. Some of the best technological minds were brought to bear on the problem, and they cranked out exhaustive and subtle analysis. Their conclusion, simply put, is that your chance of being killed by a nuclear accident is less than the chance that you will be killed by lightening. That should satisfy any person of good common sense. Did it ?

It did not. For good reasons. In 1957, after several years of unsuccessfully trying to get private industry to tool up for atomic energy, Congress passed the Price-Anderson Act. Industrialists had been reluctant to enter this new field because they were worried about their liability in case of massive accidents. Insurance companies wouldn't insure them, and they weren't about to insure themselves. So Congress stepped in.

By the terms of Price-Anderson, government and the private sector combined to insure against the cost of a single accident up to a maximum of $560 million. It is noteworthy that private industry underwrote $60 million of this, while the government's share was $500 million. The private share later rose to $95 million but we are still reminded of the celebrated recipe for "50 Percent Rabbit Pie": one horse to one rabbit.

More remarkable is the fact that beyond $560 million there is no insurance at all and – by the terms of the Price-Anderson Act – there is no legal liability. Yet at the time this act was passed there was already in existence an Atomic Energy Commission study, the so-called Brookhaven report, which concluded that a believable accident could cause $7 billion in property damage – 12,5 times the liability limit of Price-Anderson – in addition to the loss of 3.400 people killed and 43.000 injured.

What happened between 1957 and 1975 when the final Rasmussen report was released ? Several things. First: atomic energy plants in being, and on the drawing boards, grew much bigger. Second: another AEC study was carried out, but its existence was denied until 1973, and the findings released only after a Freedom of Information suit was filed. The suppression led to some justifiable suspicions, and it was no doubt to allay these that the Rasmussen study was funded. Now that that has been completed is the issue settled ?

Put Your Money Where Your Mouth is

I submit that it is not. If it is really true that the danger of nuclear accidents is less than the danger from lightning then private insurers, always interested in making money, should leap at the chance of writing nuclear accident insurance, and make a packet out of it.

But in December of 1975, 18 years after the original congressional act – and after the release of the Rasmussen report – Congress renewed the Price-Anderson Act on the same basis.

The Rasmussen report is filled with accounts of sophisticated statistical techniques (e.g., "fault trees") by which analysts seek to allow for every conceivable contingency. Very impressive. But more impressive still is the wisdom of the folk saying, *"Put your money where your mouth is".*

The atomic energy establishment, with multiple manifestations of sincerity, tells us, "It's perfectly safe". But its deeds do not match its words. If the energy industry does not show by its acts that it believes its own press releases, why should anyone else ?

What is behind the refusal of the nuclear energy industry to insure itself ? Since its spokesmen are less than candid in discussing the matter we must find our way through the thicket of facts and principles on our own. Fortunately the most significant facts do not depend on sophisticated analytical techniques.

Our first problem is to escape the mental corner the nuclear establishment would like to paint us into. Most of the two million dollars the Rasmussen committee spent was focused on the safety of reactors. But reactors are only a small part of the problem. We can grant, for the sake of argument, that the committee's views on reactor safety are sound. The report still leaves untouched some very important areas.

The Waste-Disposal Problem

For one thing, there is the matter of the safe disposal of atomic wastes. The worst of these is plutonium-239, which has a half-life of 24.300 years, by which we mean that the intensity of the radioactivity of a chunk of it diminishes by only 50 percent in 24.300 years. How does one safely store such lethally dangerous material for long periods of time ?

Simply, say the proponents of nuclear power. We first form it into rods, and then place the rods in sturdy steel cylinders. Now "sturdy steel cylinders" sound very reassuring – until we remember that the radioactive wastes put into tanks at Hanford, Washington, during the last two decades were stored in "sturdy steel" tanks – which after a few years' time started leaking like sieves. The fact is that under irradiation *all* materials change their nature. The world of radioactivity is a world of continuous inexorable change. Fuels change, containers change, reactors change. No materials are constant or reliable, except for short periods of time.

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The danger, and the change-causing effectiveness, of radioactive substances goes on essentially forever, as human beings ordinarily reckon time.

Suppose the pharaohs had built nuclear energy plants. They might have elected to store the resulting radioactive wastes inside the pyramids they built. Not a bad solution, considering how well the pyramids have lasted. But plutonium-239 stored in the oldest of them – some 4.600 years ago – would today still exhibit 88 percent of its initial radioactivity.

How much would the radioactivity have to be reduced to be "safe"? It depends on how much material we have to begin with. If the pharaohs had stored quite a lot of plutonium in the pyramids the radioactivity might have to get down to the one percent level to be "safe." If so, their initial deposits would still have more than 150.000 years to go.

Who would watch over it for so long a period of time ? The civilization of old Egypt lasted less than 2.000 years, according to the historian Arnold Toynbee. Will ours last any longer ? So far, it has lasted about 1.300 years. But 150.000 years...?

Of course, we hope to find a more enduring storage place than some old pyramid. We hope ... ERDA (the Energy Research and Development Administration), the successor to the AEC, still hasn't given the seal of approval to any storage scheme. (At one time we thought the salt mines of Kansas would be safe, but they turned out to be sieves). The proponents of nuclear power are certain that a suitable permanent storage site will be found. But is their assurance sufficient in so vital a matter ?

We are plunging ahead on atomic energy in the hope that the storage problem will be solved. Is this prudent ? What would we say if a man jumped off the World Trade Building with a bag of hardware in the hope that he would figure out a way to build a parachute on the way down ?

The People Problem

The neglect of the waste storage problem is not the only deficiency in the Rasmussen report. Much more serious is the way it fails to take account of the human factor. This failure springs from rhetoric that is peculiar to science, the rhetoric of the depersonalized passive voice.

In exhibiting the structure of a manufacturing system scientists like to use "flow diagrams," sets of little boxes with words inside, connected by arrows to show what goes where and what turns into what. The elements of a flow diagram for atomic energy production might (in abbreviated form) read like this:

> radioactive ores mined ⟶ radioactive ores transported ⟶ radioactive ores processed ⟶ radioactive concentrates transported ⟶ radioactive reactor elements formed ⟶ radioactive reactor elements transported ⟶ radioactive reactor elements installed ⟶ reactors operated and monitored reactors periodically disassembled ⟶ spent radioactive elements shipped to processing plant...

At this point, the chain doubles back on itself as the spent elements are converted to radioactive concentrates which enter the system again, while some unusable radioactive wastes go into a spur line that leads to the waste storage problem discussed earlier.

Remember, the Rasmussen report focused almost entirely on the problem of operating and monitoring reactors. The rest of the elements in the above flow list – which is much compressed – went almost unnoticed.

More dangerous still is the frame of mind fostered by the passive voice which gives no indication of the active agents – people – who cause and supervise the acts mentioned in the flow diagram. The elements of the diagram really should read as follows:

> PEOPLE mine radioactive ores ⟶ PEOPLE transport radioactive ores ⟶ PEOPLE process radioactive ores ⟶ PEOPLE transport radioactive concentrates ⟶ PEOPLE fashion radioactive reactor elements ⟶ PEOPLE transport radioactive reactor elements ⟶ PEOPLE install radioactive reactor elements ⟶ PEOPLE operate and monitor reactors ⟶ PEOPLE periodically disassemble reactors ⟶ PEOPLE ship spent radioactive reactor elements to processing plant...

By failing to mention the people involved at multitudinous points in the chain of actions, technologists may mislead the unwary (including themselves) to suppose that everything happens in a wholly impersonal system, the way acts of nature happen.

People are the quintessential element in all technology. ("Technology" comes from the Greek *tekne*, skills and arts of human beings.) Once we recognize the inescapable human nexus of all technology our attitude toward the reliability problem is fundamentally changed. It is no longer enough to ask how reliable are inanimate materials or integrated circuits; we must also ask. How reliable are human beings ? Are they reliable enough to entrust with the care of the incredibly explosive and incredibly long-lived poisons generated by atomic energy systems ?

People are unreliable in two ways: inadvertently, and deliberately. People cause genuine accidents; they also engage in deliberate sabotage and terrorism.

Accidents

Let us take up the accident problem first. The NASA program was the most rigorous, safety-oriented endeavor humankind has ever embarked on. Yet despite all precautions accidents did occur. On the Gemini 6 flight a dust cover was left off. Cost: $900.000. (But the protocols indicated this had been checked). Apollo 13 nearly failed in space because of improper voltages used in testing on the ground. Superb improvisation brought the crew back alive, but it was a near thing. (Again protocols failed to warn of the procedural error).

Still, the safety record was not bad for so large an effort. But it is doubtful if such meticulous monitoring will ever again be done: it is fiendishly expensive, and there's no such thing as "100 percent inspection." The whole atomic energy system, including as it does hundreds of thousands of people, cannot possibly be as reliable. Furthermore, we contemplate continuing it forever, whereas the NASA program was pretty much a one-time thing. It is easier to be alert and careful for a short time.

People install, inspect and monitor machines. How reliable can people be ? There is no simple, single answer. Boredom introduces a variable factor. In proportion as we make the human input into a procedure simple we thereby increase its reliability–for a while. But as people repeat simple operations year after year, without an accident, they become bored and careless. And disbelieving of the possibility of an accident. There is a sort of reciprocal relationship between the frequency of (past) accidents and the probability of (future) accidents. The smaller the first value the larger the second. This reciprocity sets some sort of undefined limit to human reliability. A long and distinguished safety record sets the stage for a serious accident at an unforeseen time.

Boredom has a second deleterious effect: the more boring a job is the more difficult it is to hire intelligent, alert caretakers. Competent overseers will, in time, be replaced by incompetent.

If someone in overall charge of an energy system dared, he might actually cause mini-accidents to happen from time to time. Perhaps a few people might be killed and a few million dollars in damage be done. Properly engineered, such accidents could, by minimizing boredom, save lives and minimize damage in the long run. But it would be much too Machiavellian to embark on such a program so we might as well forget it.

Sabotage and Terrorism

The really intractable problem in atomic energy is the problem of sabotage and terrorism. Radioactive materials can be hijacked or embezzled from many points in the system, which is far more complex than our diagram indicates. Criminals may do this within a nation. A legitimate government also can behave criminally (from an international point of view): thus India embezzled radioactive material for a bomb from the system furnished her by Canada solely for peaceful purposes.

It takes so very little material to do a great deal of damage. The "critical mass" – the quantity that is capable of exploding if it is brought all together in one chunk – of plutonium-239 is only slightly larger than a golf ball in diameter.

Given a critical mass can amateurs assemble an explosive device ? No says the atomic energy establishment. Yes says Theodore B. Taylor, who has designed more different atomic bombs than anyone else. Lacking experience and access to the most advanced technology an amateur may not devise a very good bomb, but even a "fizzle" is more destructive than anything possible before the Second World War. The prudent man believes Ted Taylor rather than the establishment, which has a vested interest in allaying our fears.

Sabotage is nothing new, of course. What is new is the magnitude of the possible damage it can do. Those who comfort themselves with the pious belief that there's nothing new under the sun should focus their attention on what has happened to what is technically called the "utility function" of terroristic action. (This utility – damage – is, of course, a negative quantity).

The expected damage is the probability of an act of sabotage multiplied by the (conditional) damage caused by a successful act. In the last 35 years the conditional damage has risen by at least six orders of magnitude; that is, it is at least a million times greater now. The maximum possible bomb before Hiroshima was measured in tons (of TNT); now it is measured in millions of tons. As for the poisonous effects of the radioactive elements released, these vary; but plutonium-239 is at least as poisonous as botulinus toxin and it lasts for tens of thousands of years. Botulinus toxin released into the environment is destroyed in a few days by microbial action.

For a negative utility to remain constant over time, if the conditional damage rises by x orders of magnitude the probability of sabotage must fall by the same number x. The conditional damage has increased a million-fold; has the probability of sabotage and terrorism decreased a million-fold since 1940 ?

I think not. In fact, I think there are a number of reasons for holding that sabotage and terrorism are more serious now than before the Second World War, and that they will grow still more serious.

For one thing there is population. The multiple pressures of different populations on each other, in a world in which the frontier as an absorbing barrier has disappeared, exacerbates both international and intranational conflicts.

Then there is tribalism. When the United Nations was founded in 1945 many of us fondly hoped it marked the beginning of the decline of nationalism. Alas ! It did not. Every decade a few more nations split, and there have been no fusions. Within many nations more and more groups demand greater privileges, in the pursuit of which they are perfectly willing to employ terrorism.

On the intellectual side, the passion for justice increases the danger of terrorism. A cold-blooded rationalist is easier to control by threats than is a passionate idealist who fights for what he perceives to be justice.

Let's put the matter this way: How would you like it if there were a complete atomic energy system now operating in the vicinity of Belfast ? or Beirut ?

This is not to say that Belfast and Beirut are intrinsically disordely communities.But they are at the moment. With the passage of time the site of greatest disorder moves from one area to another, in a way not predictable long in advance. Perhaps the United States has enough civil order to safely rely on atomic energy now – perhaps. (The area we now call Ireland may have looked safe enough in 1600; so also with Lebanon). But what about three, four, or five centuries from now ? We must remember that the danger from radioactive materials increases as we generate more and more residual radioactivity with every kilowatt of electricity. The amount of damage is hardly reduced by the slow rate of radioactive decay.

The atomic energy establishment hopes to double the size of its operations every ten years. This means doubling the amount of radioactive residues every ten years. But it takes 24.300 years for each year's residue of plutonium-239 to lose half its activity.

What is to be done ? Since it is human nature that is the most seriously unreliable element in the atomic energy system we naturally think of controlling that. But what does that mean, concretely ? It means we must establish and maintain an elaborate surveillance system affecting millions of workers in mining, processing, transporting, machining, inspecting, monitoring, and auditing radioactive materials. And the surveillers must themselves be surveilled: an infinite regress.

In the monetary area we still have not learned how to bring the embezzlement rate anywhere near zero. Yet, with respect to radioactive materials, that is what we must be able to do. Before we can do that we should call for a new Rasmussen study, this time one made by men who do not suffer from the naiveté shown by those who are merely capable scientists and engineers.

It may seem strange to call scientists naive, but there is good reason for doing so. Philip Morrisson has commented on how frequently his fellow physicists have been taken in by fraudulent extrasensory perception demonstrations, by Uri Geller and the like. Morrisson has an explanation for their naiveté. Einstein, he points out, once said that "The Lord God is subtle, but he is not malicious." The kinds of puzzles physicists try to unravel are of the utmost intellectual difficulty. Very few human beings are equal to this task. It is probably absolutely necessary, in this difficult work, that the scientist believe in the trustworthiness of nature. A physicist who thought that the laws of nature frivolously changed from time to time would probably be unable to bring the full force of his intellect to bear on his problems. Trust in nature (or nature's God) is probably essential to success.

Trust can become a habit. Unfortunately in human affairs, in some situations, trust is not the best policy. When someone tells you he can bend spoons by thought processes, communicate at a distance by non-physical means, or foretell the future accurately, your attitude toward him had better be laced with the skepticism with which you view the accomplishments of stage magicians. As Morrisson says, "Not Einstein, but Machiavelli and W.C. Fields must be your guides then." Unlike nature and nature's God, human beings can be malicious, so maliciousness is one of the variables to

be plugged into any analysis of the possible outcomes of a human-based system.

A Blue-Ribbon Committee

In terms of a human-based nuclear energy system no analysis of its safety carried out by mere scientists and engineers will be convincing. These bright men and women are for good and sufficient reason, too naive to evaluate the dangers realistically. What we need is a new Rasmussen committee which, in addition to scientists and engineers, includes people from these categories: competent prestidigitators, convicted terrorists, convicted hijackers, convicted embezzlers, convicted bankrobbers, convicted con artists, and convicted computer thieves. Oh yes: and a few certified paranoids. With a committee like that we might begin to make a little progress on the reliability problem. Such people would understand the power of malice.

Actually, impressive as such a committee would be, it would still not be the best conceivable committee. The most valuable criminals would not be convicted ones, but the criminals who are so successful in their professions that they have never been convicted. Better still, they should be unindicted. But it is operationally difficult to identify those truly successful criminals, and so we would have to settle for the second best, the convicted ones. Their records of conviction would be the equivalent of the union card or the Ph.D. degree – an assurance of training if not of high competence.

Grave Implications

With the most competent malicious men still outside the system we could expect sabotage and terrorism to continue, though at a lower level of effectiveness. But so fearful are the dangerous dimensions of "the peaceful atom" – oh, noble whitewash ! – that the toll of sabotage and terrorism (together with some simple accidents) might be such that we would come to regret the decision to make ourselves dependent on atomic energy. Desperately seeking security, we would no doubt accept more and more controls in civil life until finally we would slip into the kind of political system that can only be called totalitarian. This is not certain, but it is a real enough possibility so that we should pause before going further down the nuclear road.

Why have we started down this uncertain road ? Hans Bethe has expressed the "conventional wisdom" as well as any. He says: "This country needs power to keep its economy going. Too little power means unemployment and recession, if not worse."

What Bethe is saying is that an industrial society needs energy ("power"). But no one has ever denied this. He says that too little energy will produce unemployment and recession. Would the Chinese agree ? Their per capita energy budget is only a fraction of ours – perhaps a twentieth – but, by all accounts, everyone is employed (perhaps too thoroughly so). And the Chinese would have difficulty discerning a meaning in our word "recession". So the "too" in the phrase "too little" has no objective meaning.

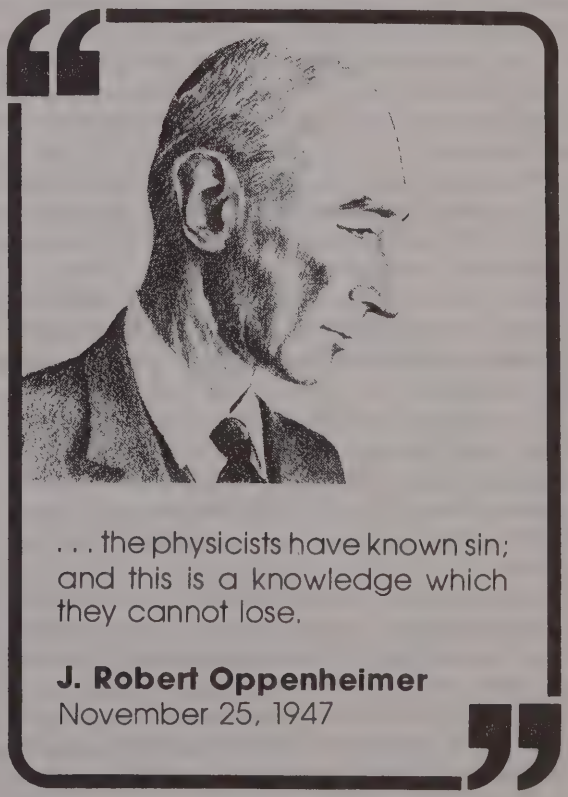
Obviously "too little" energy has meaning only with respect to some implied social, political, and economic system. Change the system appropriately and "too little" can become "quite enough" or even "too much."

For his cryptic last phrase "if not worse" I deduce that Hans Bethe is saying that a totalitarian system like China's would be worse than unemployment and recession. He may be right, he may be wrong; I will not argue the point. The significant thing I think is this: Bethe – and a host of other defenders of atomic energy – are saying that our type of society cannot survive without atomic energy. What they do not think to ask is: "Can our civilization survive *with* atomic energy ? "

One of the great guiding principles of ecology is this: *We can never do merely one thing.* Those who hope to keep our type of society intact and essentially unchanged while introducing so bizarre and dangerous a technology as atomic energy are flying in the face of ecological wisdom. Non-atomic energy will prove too little only if population and/or per capita use of energy grows indefinitely. To stop either (or both) of these from growing – or possibly even to lessen one or the other – will require that we relinquish some of the freedoms we have enjoyed for a short two centuries. The atomic apologist says that is unthinkable and so we must have atomic energy.

But, if the analysis here given is substantially correct, we can enjoy the benefits of atomic energy only if we change to the very sort of political system we reject in embracing the atom, a system in which not only the actions but to a large extent even the thoughts of its members are controlled by the state. If I were living in China I would likely argue for atomic energy rather than against it, since the danger of sabotage is much less there. (Actually, of course, if I were an ordinary Chinese citizen I wouldn't argue one way or another, because the question would not exist at my political level.)

So here is the paradox we face: *A society that cannot survive without atomic energy cannot survive with it.* The questions crying for answers are not scientific or technological; they are social, economic and political. The essential problem we must solve is the problem of living within an energy budget. Technology will not enable us to escape this problem.



FROM THE PRIMEVAL SOUP TO WORLD GOVERNMENT

An Essay on Comparative Evolution*

By Cesare Marchetti

I am Italian and you may not be aware of the fact that the Italians, through a long history of intellectual trade with the Chinese, assimilated from them a number of basic reflexes.

Now the question I have been asking myself is whether all this circus of Hydrogen Economy, Hydrogen for the Future, Hydrogen the Ecomate, is a transitory fad or has some meaning in a larger context.

If I were American, I would set up a dynamic model of the world economy and try to guess what's the meaning of hydrogen through that model. Not being American, I do not like dynamic models - they too closely resemble cembalo-playing automatons. So what I did do is what any well-bred Chinese would do: look in the book of history to see whether a precedent exists, and from that precedent deduce the future - because history tends to repeat itself, and precedents contain physiological information about the ways things work in the real world. So in order to solve my problem I opened a very large book: the book of Nature, or more precisely the book of the Earth. I will try to convey to you the results of my observations, or, if you like, meditation and interpretation, as book – and in particular history book – have to be interpreted. This is somewhat equivocal because you may then put what you like into them, but I will try to rationalize my interpretation so that my personal feelings will not emerge.

Well, to begin at the beginning as Alice said, about four billion years ago the Earth started to take on what can be considered the soft form of its present state. It was a well established planet in the solar system, the crust was solidifying, and the basic amount of gases, water in particular, had already come out of the degassing rocks. Our history then starts four billion years ago, or - as physicists say - four G-years ago.

The primeval atmosphere of the earth was essentially a reducing one. This may seem a point of detail, but it is extremely important. I can tell you in anticipation that most of our metabolism is based on a chemistry that is typical of a reducing ambient *just because* four billion years ago the atmosphere of the earth was a reducing one.

The reason why the atmosphere was in a reducing state is that the Earth as a whole is essentially in a reduced state. You can think of all the iron in the core of the earth as metallic iron, and it is natural for the gases coming out to be in a reduced state, or to become reduced, e.g. by the iron lying around at the surface. This atmosphere was made up of a very complicated mixture of gases: hydrogen, water, CO_2, nitrogen, ammonia, hydrogen sulphide; and the sun was injecting its usual amount of radiation into the system. So very probably there was also an atmospheric circulation, clouds, rain and lightning.

By various mechanisms, the energy introduced by the sun produced excitation and reactions between the molecules of the atmosphere, and quenching preserved the products even in non-equilibrium states. One can to some extent reconstruct what happened, for example by electric discharges in such a mixture of gases, and generate a complex set of molecules that we may call organic molecules because they are very similar to those produced by living organisms. Apart from electric discharges, other processes were active in this transformation, through ultraviolet light, the proton wind from the sun, and even hot magma. And this went on and on for a number of years, let us say half a G-year, without anything new really happening except a continuous increase in the number of these molecules concentrated in various configurations. One may have the diluted solutions in large seas, and the concentrated ones and even precipitates in lakes, where evaporation and rain operated as a kind of soxlet. This is the "Primeval Soup".

The thermodynamic non-equilibrium of this broth, conserved by kinetic hindrances, constituted a negentropy dowry that gave purpose to astute manipulators. And the immense complexity and potential of organic chemistry gave them a chance. Although we have a fairly satisfactory log of information from geological evidence, from the immense capacity of living organisms to conserve information, and from continuity, what happened is in many ways obscure and certainly perplexing: some of the molecules banded together to rob other molecules of their free energy in order to support and reproduce their organization.

What these "catalysts" looked like is a fair guess, even if the rules of chemistry and of continuity greatly restrict the range of possible configurations. I like to see them as protoviruses pilfering in concentrated pools of soup as they now exploit the protoplasm of cells.

In a reducing environment, the first self-organizing and reproducing catalytic systems could draw negentropy from a conceptually restricted number of operations, essentially molecular reorganizations, where hydrogen represented the mobile component. This hydrogen shuffling is called transhydrogenation and is at the base of all fermentation processes, and of the biochemistry of living systems.

This was probably the most momentous period in the whole evolution of life. The basic technology was created and established, and the basic invention of the founding fathers still constitutes the core of our metabolism. People, are basically anaerobic fermenters with an "inboard" respiratory system.

The consequences of the technological breakthrough are easy to predict: faster and faster population growth, and exhaustion of the reserves that abiotic processes had accumulated in the primeval broth. In this Malthusian situation one can easily imagine the struggle for new biological niches - tricks for extracting negentropy from more and more sophisticated molecular scrambles and more and more and more diluted solutions.

*) Adapted from a banquet address given at the First World Hydrogen Conference, Miami, March 1-3, 1976, and reprinted by permission of the leaders of that Conference.

The analogy with the last 200 years of the evolution of our society is striking, and you are probably burning to know what happens then. Final disaster to complete destruction of the biosystem ? "Black death" reducing the level of life to the level of natural input of fermentable molecules ? Development of "communes" characterized by less technologically aggressive behaviour and stably fitted into econiches such as isolated lakes ?

No. Actually the first half billion years of rapacious archeo-capitalistic exploitation of primary and non-renewable resources of soup had also generated something positive and of lasting value: an enormously sophisticated technology, flexible and capable of evolution - the technology of life. It is this that brought the technological fix to tap a new large source of negentropy.

The 300.000 TW of free energy the sun pours over the Earth were the obvious candidate source, although the ultraviolet component of sunlight, not yet filtered by the ozone layer, was an extreme radiation hazard for living organisms to deal with, genetic damage being the least thing that could happen and death the easiest. Sitting on top of three extra G-years we can safely say that there are other possibilities. One of them is to exploit fission or fusion, but in order to get to that the system still had to go through three fundamental breakthroughs: the eucaryotic organization, sex, and language.

Eucaryotic organization brought formally a centralization and rationalization of functions in the cell, but substantially the capacity to manipulate and control amounts of information larger by various orders of magnitude. Sex gave the possibility of transferring genetic information transversally, across the species, making the total genetic pool available for recombination. This enormously increased the speed of evolution, and hierarchically organized cell systems evolved up to man in a mere G-year.

Language plays a similar role, but evolution can now take a lysenkovian character and applies essentially to a kind of human ectoplasm: the machine.

Coming back to our desperate and courageous guys - the bacteria - they really had no option but the sun or bust. But how did they manage ? One of various tricks invented during their "industrial revolution" was to separate the system capable of extracting free energy from the external molecules from the system using this energy. The separation was made by active chemi-osmotic membranes generating an energetic product which in its action very much resembles electricity: adenosintriphosphate.

This extraordinarily important and extraordinarily "archaic" energy carrier is certainly worth a digression. It was the basic energy carrier between the machinery operating the trans-hydrogenation and the living machinery synthesizing e.g. DNA and proteins. The rationale is that the increasing complexity of the mechanisms of life was isolated from the characteristics of the various primary energy sources, just as electricity "isolates" a computer from coal and oil chemistry.

The similarities of adenosintriphosphate (ATP) to electricity appear in various ways. First, it is a cycling molecule. It is made at a *phosphorylating membrane* (the fuel cell !) by attaching a phosphate ion to adenosindiphosphate (ADP). This requires about 8 Kcal/mole. It then reverts to ADP at the business end.

Now this chemical circulation is extremely fast, almost like that of electrons in a conductor. Just to give an idea, a man produces his weight of ATP every day, and consumes it: the amount of ATP present in our body is just a few grams. For bacteria the rate can be a thousand times higher.

ATP is a kind of DC electricity, and Edison would be happy with it, as it operates at a single voltage of about .15 V. There are no transformers and consequently it is not very transportable. It is in fact generated and consumed at the level of the cell travelling only a few microns. A reaction requiring a higher "voltage" is graded in a series of intermediate steps, each of them operable by ATP.

The breakthrough that led to the exploitation of light was the discovery that photosensitive pigments could be associated with the phosphorylating membrane, so that the pumping of electrons (or better protons) necessary to make ATP could be done through the absorption of quanta of light. In this way phosphorylation, i.e. production of ATP, could take place in the absence of fermentation. The fuel cell had become a photo-electric cell: photosynthetic bacteria had been invented.

Photosensitivity must have been around for a while, as a special case of chemical sensitivity. It was obviously an advantage to move in the right direction across the concentration gradients of the soup, and as it came down from the atmosphere, the soup was richer near its surface. But light, not filtered of its ultraviolet in the reducing atmosphere, was a killer, and had to be avoided. The new trick was really a relatively simple invention, but of sweeping importance. Incidentally, a single species of bacteria (perhaps a living fossil) still uses a vision receptor, retinal, for phosphorylation.

The laboratory-rigged photocell soon became an apparatus of intricate structure and high efficiency, but this is just development. The key issue is that sunlight was tapped. We too have tapped nuclear energy by making electricity first, for very similar reasons.

So "electricity" was produced by a photocell, and the free-energy umbilical link with the primeval soup was severed. However, if you keep growing other boundary conditions will pop up, and then you again start having problems, as the Club of Rome keeps reminding us.

The next problem was a materials procurement one: getting enough building material to make the biomass grow. It was normally quarried in the primeval soup, but through many mechanisms destroyed - broken down or not recycled. Oil may become short also for petro-chemicals after becoming short as fuel.

Now by far the largest amount of carbon available was in the form of carbon dioxide, and so the next step was to try to reduce carbon dioxide. The basic machinery already existed: bacteria had long used hydrogen, available from the atmosphere or from partial fermentation, to reduce CO_2 to methane. So the real problem was to find a new source of hydrogen.

A substrate from which hydrogen can be extracted relatively easily is hydrogen sulphide, and bacteria rapidly found a way to that. Most of the sulphur reserves we are mining now are just the tailings of this operation. What the bacteria were unable to do, however, with their low-voltage DC - that is, ATP produced by photophosphorylation - was to extract hydrogen from water, liberating oxygen as they liberate sulphur, an operation that is an order of magnitude more difficult.

Now bacteria trying to extract hydrogen from water by using light were in a situation extraodinarily similar to ours in trying to split water using nuclear heat. A single photon, even of blue light, had insufficient energy to pump an atom of hydrogen out of the water, just as the temperature of our reactors, even HTR, is insufficient to crack water thermally. But the restless exploration for new techniques finally led to the solution.

What the genius of the era hit upon was the simple and efficient idea of a *two-step* photochemical process to decompose water ! The new organism - *the plant* - could now draw from the "infinite" resources of water, carbon dioxide and sunlight. So you see, by going from a single-step photoelectric process to a two-step photochemical process a quintessential breakthrough was reached in the living orga-

nism: independence, energetic independence and materials independence - and the umbilical link with the primeval soup was finally severed.

The problem of energy storage and transportation, so important later on for the development of complex organisms, was also solved at this point, as plants used the hydrogen to synthesize carbohydrates and fats. One is tempted to call them synthetic fuels.

Curiously enough, one of the ways explored by photosynthetic bacteria for extracting hydrogen from water, and occasionally used by them even today, required an oxygen acceptor to be taken from the soup and strictly resembles nuclear-assisted steam reforming of natural gas, or coal gasification, both one-step processes.

One of the side effects of this breakthrough was that immense amounts of oxygen were liberated. These slowly changed the essential nature of the primeval atmosphere, transforming it from a reducing to an oxidizing one. But the change was not only chemical. Most important, the presence of free oxygen in the atmosphere brought with it a change in the nature of the light reaching the surface of the Earth. As I said before, in a reducing atmosphere the ultraviolet tail of the solar light reached the surface of the Earth and would have destroyed the already sophisticated chemical mechanisms of the protobionts. They had to thrive in the warm womb of the ocean.

What the oxygen brought was a filtering of the short UV by the formation of an ozone in the stratosphere. Now living organisms could finally come out of the water and conquer the land. This can be viewed in another way; *life had grown to take control of the environment on a global scale,* and still holds it fast. To give one example of many, nitrogen is not at equilibrium in the atmosphere as it can combine with oxygen and water and go to a solution of nitric acid. This is thermodynamically possible and goes on all the time through various routes. Without a global counteraction the ocean would become a horrible pickle and life would be destroyed. The homeostatic feedback comes from a *geo-engineering* operation of bacteria, living in the ooze at the ocean bottom or in the mud on land, which use the nitrogen oxides diffusing there to oxidize organic materials in the ooze. So oxygen is given back as CO_2, and nitrogen as such. Many such homeostatic feedbacks are operated by the biosphere, and this keeps our earth liveable.

Now, if humanity starts producing hydrogen from water using "new" sources of free energy - fission, fusion, or perhaps directly tapping the old sun - and moves away from fossil fuels, which in my analogy are the equivalent of the primeval soup, what kind of new control of the environment can occur as byproducts of this operation ?

One of the reasons why I was led to the development of the hydrogen economy is the realization that the structure of an energy system is very strongly influenced by the physical and technological characteristics of the energy vector. I can give an example that comes from an existing energy system, the electric one. If you assume that electrical systems are continually reoptimized, you will find that a particular configuration that exists at a certain time results from the competition between two or three different requirements. One is that there is an economy of scale for a power station; this pushes toward building larger and larger stations. There is, however, a diseconomy in transporting electricity over large distances and this asks the system for small, dispersed generating stations. And then the diseconomy of scale comes from the fact that the reliability or availability of the electrical net has to be much larger than the availability of a single power station, so that you must have a standby in case of machine failure. Standbys are cheaper if the machines are small, and so you have another force pulling towards small power plants.

Electricity is now transported at a mean distance of 100 km, and we'll call that the characteristic dimension of the unit cell. If you increase the transportability of your energy vector - say by using higher voltages, or better, by switching to hydrogen which has an economic transportability of about 1000 km - then the unit cell will grow to that size and the system will grow homothetically, with the optimal size for power stations 100 times larger than before.

A counter-proof of this reasoning comes from the evolution of the electrical system during this century, where the size of the cell doubled roughly every 22 years, and the density of the consumption inside the cell roughly every ten years. Combining the two growth factors, one finds a doubling of the power of the cell every 6.5 years. The statistics on the size of the largest generators installed during the last 80 years tell us their power consistently doubled every 6.5 years through five orders of magnitude !

Now with hydrogen as an energy vector, a unit cell of 1000 km takes the dimensions of a continent or a subcontinent: the USA may have three or four cells, Western Europe one or two, and the optimal size of the generating plants would be two orders of magnitude larger than for electricity.

That is for hydrogen transported by pipeline. But if we look farther into the future and assume that LH_2 can be economically generated and transported by tankers, as a kind of evolutionary trend of the present technology for liquid natural gas, then our economical distance may well become 10.000 km. Then the unit cell is the world, and the optimal configuration would be to generate all the energy on ten sites. Ten is the magic number that comes from the standby constraint in the optimization.

As humanity now uses about 7 TW of primary energy, each site would then have one TW and should obviously be located on the seashore or better on an island in the middle of the ocean. The investment per site would be in the order of hundreds of G-dollars, and this means that such an operation will become technically and economically the most important in the world. What could be the political implications ?

In a nutshell, a state can be seen as a vertically integrated power system filling a geographical area. A multinational is a horizontal power system organizing a thin layer of human activities without precise geographical boundaries. The horizontal power generates "confusion" and loss of control by the vertical one and, with the layers thickening, will inevitably lock with it. The ostensible muck-raking against multinationals is a clear symptom of that. But what will be the outcome ? Following my Chinese reflexes, I opened the history book again in search of precedents, and unexpectedly the search brought interesting results.

A fight between geographically bound political powers and a pervasive horizontal power went on in the Middle Ages. The multinational of the time was the Church, as you well know interfering and competing in many ways with the geographically fragmented political power of the time.

As the two power systems cannot be interchanged nor either one eliminated, a compromise finally had to be worked out. The political power handed its thin top layer to a supernational power structure, producing a kind of political multinational: the Holy Roman Empire. The manoeuvering space of the emperor was politically narrow, but territorially broad and at the proper hierarchical level of abstraction to deal with the Pope on an even basis.

My educated analogy says that the outcome will be a world government, or more flexibly defined, a world authority to make a dialogue possible.

Energy is the largest single business in the world. At $12/bbl for oil the turnover is G$500/year. It will be G$2000 at the beginning of the next century. This means

that energy multinationals will be the strongest forces in the struggle with the political power, and their field of activity a sensitive one. The system attraction of the ten-islands scheme will make this inevitable, and the issue exquisitely political.

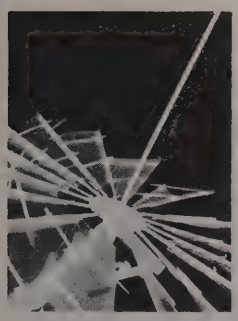
Very large energy centres, and energy generation as a world operation, are direct consequences of the technological process of watersplitting, and they may modify the political atmosphere, just as oxygen did for the Earth atmosphere, leading finally to a world goverment.

The grand design is deploying itself, and we have the privilege and the responsibility of living at a great turning point in history.

SUMMARY

The problems mankind is facing in the search for energy resources and ways of using energy should not be *a priori* different from those encountered by biosystems in the course of their evolution: we live in the same world and the rules of the game are similar.

How the analogy can be drawn is shown in this paper; so too is the excellent fit between the two evolutionary paths. A very tentative scenario is drawn for the future, by extending the parallelism a bit forward in time.



TECHNOLOGY AND SELF-RELIANCE *

By A.K.N. Reddy

Scratch any piece of technology and you will find the values and aims of a society it was designed to serve. For technology is like genetic material – it carries with it the code of the society which conceived it.

That is why the choice of technology is such a crucial decision for the developing countries today. The kind of society and the kind of environment which they will create depends to a large extent on what technology they choose for the job of development.

There are several possible technologies, for example, for increasing fertiliser production – a task which almost all developing countries are now setting themselves. How does the choice of technology for that job affect the kind of society and the kind of environment created ?

One possible choice is the installation of large coal-based fertiliser factories. Another is the building of small bio-gas plants at village level. The bio-gas plant breaks down human and animal wastes into a rich fertiliser and releases energy in the form of methane gas which can be used for cooking. The table below summarises the different impacts of the two methods.

The target for each method is the same – 230.000 tons of nitrogen fertiliser per year.

Firstly, the choice of village level bio-gas technology bases fertiliser production on renewable wastes as opposed to non-renewable resources.

Secondly, the bio-gas plant is non-polluting, whereas the coal-based fertiliser plant causes serious atmospheric pollution by emission of carbon dioxide.

On the economic front, the small-scale village bio-gas alternative saves $15 million of precious capital and $70 million of foreign exchange in countries which have acute capital shortages and balance of payments crises. In addition the bio-gas plants yield a higher return on investment and deliver the urgently needed fertiliser more quickly – because the small plants can be brought to full production capacity in months whereas the large coal-based plant takes years to build and tune up to full production.

In terms of social development, the choice of bio-gas technology disperses production to 26.150 villages rather than concentrating output in one centre. So the benefits of development are spread more evenly. At the same time, it generates 130 times as much employment in countries where unemployment is one of the greatest perpetuators of poverty. And it provides that employment where it is most needed – in the poorer rural areas where the majority of the population still lives. In so doing, it also helps to arrest the disastrous drift to the slums and shanty-towns which surround many of the Third World's cities.

In terms of "infrastructure", the choice of bio-gas produces the fertiliser where it is to be used, so avoiding the costs of packaging, marketing, advertising and transport and taking the strain of the already overloaded road and rail systems of the developing world. Not least, it frees the villager from dependence on the usually corrupt and inefficient systems for getting the fertiliser from the urban producer to the rural user.

In terms of the New Economic Order the choice of the small-scale village level technology reduces the developing country's dependence on the developed world because the technology of bio-gas plants can be indigenously evolved whereas the technology of large coal-based fertiliser plants usually has to be imported from the West.

The list of advantages does not end here. Self-reliance and meeting of basic needs are the very foundations of development and genuine progress. And it is in this respect that the decentralised village scale bio-gas choice really comes into its own. It can mean increased self-reliance in two fundamental needs – fertiliser for growing more food and energy for cooking it.

* This paper by Prof. Reddy is distributed by the U.N. Environment Programme under the title "To Choose a Future". Prof. Reddy is completing a one-year assignment with the U.N. Environment Programme in Nairobi.

The output from each village bio-gas plant can provide two and a half times the nitrogen fertiliser now used on the 290 cultivated acres of the average Indian village. And this significant increase can be achieved by using the body waste from 500 human beings and 250 cattle. As 60% of India's villages have a population of under 500 and as the ratio of people to cattle is roughly 2:1 this means that most of India's villages can more than double their fertiliser use from their own renewable resources. That alone could be a great stride forward in self-reliance.

But finally there is the crucial question of energy needs. The city-based power station in the developing world rarely provides energy for the rural areas. The typical energy allocation of these centralised power stations is 80% to urban industry, 10% to urban homes and 10% to rural areas. In India for example, only about 11% of the villages with a population under 500 have electricity.

This energy starvation in the rural areas has profound effects on many aspects of development. If, for example, a rural family has to spend four to six hours per day bringing drinking water from a well or a stream, and another four to six hours a day collecting firewood for cooking fuel, and another four to six hours per day grazing the cattle, then the only way the family can manage this is by having a large number of children. Indeed, millions of poor families depend today on the "energy contribution" of children for survival. So anything which will increase the available energy in a village will speed up development and eventually slow down population growth by making it less necessary to have large families.

The choice of bio-gas technology for fertiliser production could provide that essential energy. A crude estimate of the energy needs in a village of 100 houses and 500 people is about 200 kw/h. per day for cooking; about the same for water pumping and small industry; and about 100 kw/h. for lighting. That is a total of roughly 500 kw/h. per day. The 5.000 cubic feet of bio-gas which is produced as a "by-product" of making fertiliser out of animal and body wastes is the equal of about 660 kw/h. per day.

So this particular choice of technology has another crucial implication – the Western coal-based fertiliser technology implies *consuming* energy equivalent to the needs of about 550 villages, whereas the alternative bio-gas fertiliser technology helps in *producing* the energy to help meet the needs of 26.150 villages and of the poor in those villages.

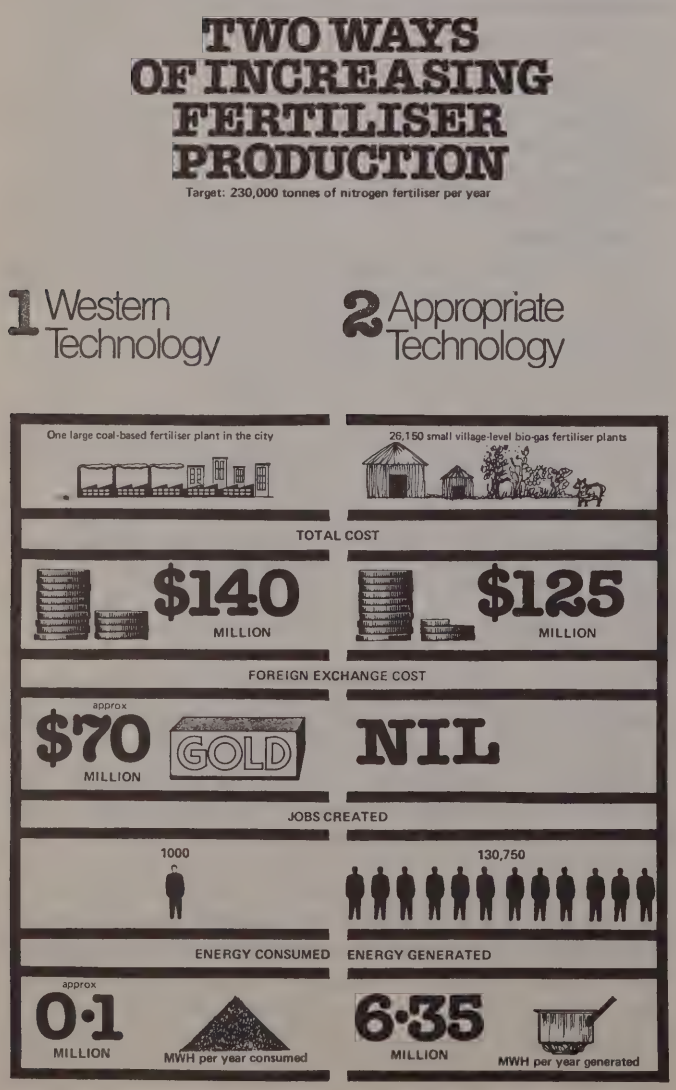
The problem of distributing bio-gas cooking fuel to individual houses can be transformed into an advantage by using plastic pipes which convey clean drinking water at certain times of the day and bio-gas at the peak cooking hours. A protected water supply system of this kind, in conjunction with latrines that feed human wastes into the anaerobic digester of the bio-gas fertiliser plant, may prove to be a breakthrough not only in meeting energy needs but also in providing low cost public health technology to eradicate the water-related diseases which are a major public health problem in almost all developing countries.

Lastly, the creation, operation, maintenance and management of the bio-gas fertiliser plant by village people can be a vital catalyst in stimulating and sustaining social participation and people's control which are the surest guarantees of real development.

The example of bio-gas fertiliser production shows in capsule form why the choice of Western technology for most developing countries wastes scarce capital, concentrates benefits in urban areas, restricts rural employment opportunities, accelerates the drift to the urban slums, squanders foreign exchange, puts the village at the mercy of the towns, increases dependence on the developed countries, undermines self-reliance and the meeting of basic needs, and defeats and distorts the developed process.

Whilst the prolific development of Western technology has led to spectacular increases in production, it has also shown an inbuilt tendency to damage the environment, reduce participation in the decision-making process, and magnify inequalities between and within countries.

By contrast, alternative technology such as the small-scale bio-gas plants is in harmony with the environment and with genuine development. It tends to reduce inequalities, to meet real needs instead of artificial demands, and to increase self-reliance and participation by people in the decisions which affect their lives. Without a commitment to new and alternative technology, there cannot be a real advance towards meaningful development, towards a new economic order and, indeed, towards a new world.



THE CONTRIBUTION OF FAITH, SCIENCE AND TECHNOLOGY IN THE STRUGGLE FOR A JUST AND SUSTAINABLE SOCIETY

(Proposals for the Programme of Church and Society, 1976-1981)

INTRODUCTION

We find ourselves at a turning point in human history. A new social order that is both just and sustainable must emerge if catastrophe is to be avoided. Time is of the essence. Some believe that it is already too late; others believe that science and technology can still find ways out. However robust, the faith of yesterday in the power of science and technology is today misplaced and therefore misleading. In fact the reductionist, triumphalist, manipulative approach of science and technology has itself been in large part responsible for our predicament.

Reason and benevolence, together with the application of resources and power cannot save us. We have for too long tinkered with the problems of justice and development, with the best of wills and most generous programmes of aid and education, to now be able to believe that more tinkering will do the trick. We live in a self-destructive social order in which only radical solutions can be effective.

Christians can neither panic in the face of possible catastrophe nor retreat to a pious position of do-nothing apocalypticism. Can they, on the other hand, be confident that catastrophe can be avoided through radical action ? Our faith gives us no such guarantee. However, the confidence of faith, that whether we live or whether we die we are in Christ, gives us the liberty to do what we must without panic or despair, but also without any false optimism about the final outcome.

We believe that time is not infinite, that history will end, that the present heaven and earth will pass away, that the new heaven and the new earth will come, that the Kingdom of God is not something that happens in linear continuity with history. In this sense, Christians are not naïve utopians or simple optimists who identify this just and sustainable society with the Kingdom of God. We know that the way to the resurrection leads through the Cross, that the way to life leads through death.

Yet we also believe that the Kingdom has already broken forth into history, that human beings are stewards of nature and history, that we are answerable to God for the way we manage the planet, that the way society is organized should not be self-destructive or unjust, and that we will not escape condemnation if we bury our talent and do nothing. In this context we dare to strive for a just and sustainable society. The joy of love, not the fear of catastrophe, motivates our action in the present crisis.

I. THE NATURE OF THE JUST AND SUSTAINABLE GLOBAL SOCIETY

Our existing global society is neither just nor sustainable. Population growth and economic growth cannot continue indefinitely along past and present patterns without the collapse of much that sustains life. We are seeing some evidence of this now in regional famines, the oil-energy crisis and the hazards of high technology. The poor always suffer first and those who suffer most are always the poor. Even now half the world's population is suffering from malnutrition or starvation or both. According to the World Bank, 755 million people are in absolute poverty with an annual income of US$50 or less. In 1970, the difference in average per capita income between developed and developing countries was US$2.200. If the present pattern persists, the absolute gap will increase enormously.

The twin issues around which the world's future revolves are justice and ecology. "Justice" points to the necessity of correcting mal-distribution of the products of the earth and of bridging the gap between rich and poor countries. "Ecology" points to humanity's dependence upon the earth. Society must be so organized as to sustain the earth so that a sufficient quality of material and cultural life for humanity may itself be sustained indefinitely. A sustainable society which is unjust can hardly be worth sustaining. A just society that is unsustainable is self-defeating. Humanity now has the responsability to make a deliberate transition to a just and sustainable global society.

The just and sustainable global society will be one in which people everywhere will participate in making the decisions that affect them. It will be a society in which each one can feel secure that his or her quality of life be maintained at an acceptable level. The need for food at any one time will be well below the global capacity to supply it. The rate of use of non-renewable resources will not outrun the increase in resources made available through technological innovation. The emission of pollutants will be well below the capacity of the earth to absorb them. With its material

needs of food and shelter satisfied, such a society will be free actively to pursue quality of life in a variety of non-material dimensions such as recreation, leisure, arts and education.

The just and sustainable society is conceived as one in which the numbers of people, their rate of use of resources and the rate of pollution of the biosphere are within the capacity of the earth to support. The distribution of resources is such that an acceptable quality of life can be sustained indefinitely for all people. As the report of Section VI to the Nairobi Assembly stated, "This will involve a radical transformation of civilization, new technology, new uses of technology and new global, economic and political systems. The new situation in which humanity finds itself has been created in less than a generation. There is even less time to create the transition to a sustainable global society if humanity is to survive."

The transition to the just and sustainable society will for the rich world involve population control, reduced growth in production of consumer goods but not in essential services, and conversion to more appropriate, less polluting technologies. For the poor world it will involve population control, and increased growth in production of both consumer goods and essential services by means of socially and ecologically appropriate technology. For the world as a whole, the transition to the just and sustainable society will involve a distribution of resources that is more just than at present by means of a new international economic order. There will be a new role for science and technology to develop ways of "farming" the resources of the earth while at the same time maintaining the integrity of the natural life-support of the biosphere.

Hence the just and sustainable society will involve a new understanding of (1) the role of science and technology in human affairs and (2) the meaning and purpose of creation and the place of science and technology in relation to it.

II. ETHICAL, ECONOMIC AND POLITICAL PROBLEMS IN THE TRANSITION TO A JUST, PARTICIPATORY AND SUSTAINABLE SOCIETY

In order to begin the transition to the just and sustainable society there is need for study of the following issues:

- The reordering of the patterns of production and consumption in rich countries and the need to find new and diverse patterns of employment. Already industrial growth is constrained for a variety of reasons and consequently fewer people are finding employment in manufacturing industry. In some countries the problem of young people entering employment for the first time has been met by the necessary implementation of labour intensive job creation schemes at the community level. The alternative prospects in a slowly growing economy is for this level of unskilled labour to be denied the right to work. Governments are already obliged to accept the necessity of a shorter working week. It is therefore inevitable that the movement towards a sustainable rate of productivity will demand more flexible working conditions and more creative employment opportunities.
- A higher proportion of old people in the population will bring problems of a possible shortage of labour and of how to ensure that old people have the opportunity to fully contribute to the activities of society.
- The sort of stimulus to life presently provided by growth in size will need to be replaced by other stimuli, such as growth in diversity of creative pursuits.
- The political realities involved for rich and powerful countries in beginning a programme of de-development. Can it be done while they are still pursuing an arms race ? Can it be done by one country at a time ? Or does it involve group action ? What possibility is there of the rich centrally planned economies participating in the process ?
- The impact on the poor countries of stabilization of production and consumption in the industrialized world. The changes in international economic relationships, if de-development of the rich is to contribute to real development of the poor countries. (Extension of the W.C.C. involvement in the U.N. debate on the New International Economic Order).
- Whether foreign capital and expertise can be utilized transnationally in a constructive way without the traditional element of exploitation.
- Alternative development strategies for poor countries compatible with the sustainable and just social order and with the principle of self-reliance.
- Alternative technologies for both rich and poor countries that are less risky and more ecologically appropriate, less polluting and less wasteful, on a smaller scale, and involving recycling.
- Participation of people in decision-making in the transition to a just and sustainable society. This means much more than the vote, particularly in developing countries. It has more to do with the organization of voluntary mass movements at the grass-roots level, so that people are not merely objects of manipulation by power groups or the passive recipients of the fruits of government planning. They themselves must devise new ways of production and distribution, consonant with justice and sustainability.
- Non-expert participation in discussions about alternative technologies, in weighing the risks and assessing the benefits. The non-expert has extreme difficulty in making decisions, when confronted with experts who have divergent views as, for example, in the nuclear power debate. The technique of public inquiry at a local or community level needs to be developed. Prior to that, there must be a clarification of the relevant complex issues so that they can be presented to the non-expert in the clearest possible way.
- Dramatizing the issues of the just and sustainable society in such a way that people may be persuaded to a change of heart and mind on the necessity of beginning the transition to this new global society. What is the role of theology and of the churches in this process ? (Some leads have already been given, as, for example, the Evangelical Life Style programme of the American Baptist Convention and the Technology and Society project of the Church of Scotland.)

– Exploration of immediate steps which rich countries can take that lead in the direction of the just and sustainable society. (Involving the extension of the W.C.C. involvement in the U.N. debate on the New International Economic Oeder.)
– The utopian possibility of some sort of international control in certain fields should not fade into the background. For example, the international control of defence, pollution, and resource rationing, and the possibility of a global progressive income tax levied and reallocated by an international body.
– The planning and management of larger urban areas as an ethical, technological and social concern and ways of decentralizing populations.

Recommendations:

1. That Church and Society be responsible for planning a world conference on the Just and Sustainable Society before the next Assembly (1979). All the elements in the reflection-action programme outlined below should be viewed as inputs or outputs of this conference. A small Working Group should shortly produce a document of some 20-25 pages on the just and sustainable society as a prospectus to initiate the study project.
2. A consultation of economists together with some ecologists, trade unionists, industrialists and technologists to face up to the problems of economic planning for a just and sustainable society at national and other levels, in contrast to traditional concepts of economic growth, particulary in the industrialized countries. (The economists should be drawn from market economies, centrally planned economies, and from developing and developed countries.)
3. A consultation of young people (including young scientists, workers, and business executives) on the problems of the just and sustainable society.

III. SCIENTIFIC AND TECHNICAL PROBLEMS AND THE ETHICAL ISSUES INVOLVED IN THE TRANSITION TO A JUST AND SUSTAINABLE SOCIETY

A. Risk Assessment and Appropriate Technology

The technology of the rich nations is based on the replacement of labour by sophisticated capital equipment, the application of science to industrial processes, and large-scale production. All this has helped to bring a higher material standard of living to nearly all people in rich nations, though partly at the expense of the world's poor. As organized at present, the system is wasteful of resources (partly through its stimulation of artificial consumer demand), and tends excessively to pollute the environment through its multitude of artificial products and wastes. Moreover, its complexity and short-term rigidity make it vulnerable to disturbance in its economic, social or natural environment. In spite of all the expense and sophistication of high technology, there is far more careless and irresponsible design and operation than is generally realized (supertankers, major chemical hazards, asbestos), and also a significant degree of incompetence and complicity among regulatory agencies.

Each major innovation in high technology tends to become a "superstar", which, while bringing benefits also, often demands vast resources, causes far-reaching environmental changes, and controls most of the expertise required for effective monitoring. Estimating the risks of such new technologies can become an exercise in guessing exceedingly low probabilities of accidents, combined with the high human and environmental costs should they occur.

An appropriate technology should aim to satisfy needs, while aiming to reduce resource-consumption, pollution, and the oppression and alienation of people. There can be no recipe for such a technology, or for an ordering of its goals. If it is to be appropriate for people, it must relate to their local habitat – land, climate, resources, history and culture. It is not necessarily small-scale, labour intensive or simple in design, for different functions require different tools. When we consider the cumulative effects of a new technology, we try to speculate about the risks and benefits, while still being uncertain about all the facts. Often very few relevant undisputed scientific facts exist to help the community to make decisions that may profoundly influence its future. But a broad choice between technologies is better made on genuinely ethical criteria, rather than on calculations with quantities that are very imprecise, and influenced by implicit ideological bias. Nevertheless, we also recognize that all decisions, good and bad, are made under conditions of uncertainty, and that reducing the extent of the uncertainty by enlarging the base of the even handed facts should concern us all.

Recommendation:

A small consultation in 1977(?) on risk assessment and appropriate technology, and the relation of the new sort of science and technology, to economic and political thought and action.

B. Agricultural Technology and the Food Crisis

We identify four areas of concern for the W.C.C. (to be examined in cooperation with CCPD):

1. Emergency world food reserve for use in the event of wide-spread crop failures or other natural disasters.
2. Development of appropriate food technologies that are ecologically sound and compatible with self-reliant development. The main need is in the tropics where some 5.000 million people will be living at the end of the century and where most of the food will have to be produced where it is needed.
3. Critique of present food technologies in developed countries (e.g. the energy intensive operations of modern agriculture), and the use of food as a "political weapon".
4. New life style in consumption.

There is need for people, especially in the developed countries, to make a new moral commitment, to reduce unnecessary consumption of food and energy and to conserve these resources. At the same time, the problem of how reduced consumption in the developed world will help to make resources available to the poorer world should be pursued. (See also Section C.)

Recommendations:

1. That a small group of about five experts on food and agricultural technology, meet with staff in Geneva to discuss areas of agricultural technology on which it would be appropriate for Church and Society to focus in relation to the just and sustainable society.

2. That a consultation be held on "New Life Style" to share ideas and strengthen common efforts to reduce consumption of food and energy in rich countries (in collaboration with Programme Unit III).

C. Energy for a Just and Sustainable Society

Energy is essential for all human living. It is therefore the focus for many ethical, social and theological issues that cannot be evaded by the churches. Energy was one of the technological areas which the Nairobi Assembly singled out for special attention. The Assembly asked specifically that the churches in cooperation with the W.C.C. continue the work of the Bucharest and Sigtuna conferences on "energy planning in a Christian context", emphasizing especially energy conservation, the need for additional safeguards in the control and operation of nuclear energy and its fuel cycle, and the development of alternative energy technologies.

Provision for the energy needs of the world in the immediate and foreseeable future will require:

- Increased use of energy for a large part of the world's population and a wiser and more efficient use of it everywhere;
- safeguards against the dangers in many ways of producing energy;
- more equitable distribution of energy, and changes in life styles and in social and political institutions to achieve greater conservation of energy by many people and greater access for many more.

The Core Group, having received the advice of a number of expert consultants on energy needs, proposes an immediate action programme for the W.C.C. as well as a substantive programme of ecumenical research and study.

An Immediate Action – "Energy for my Neighbour"

In view of the urgency relating to world energy needs, the Core Group asks the Central Committee of the W.C.C. to initiate a programme of action, "Energy for my Neighbour", calling on its member churches and their membership in the developed countries to resolve during a three-year trial period, beginning in 1977,

a. to reduce their energy consumption by x per cent;
b. to contribute the financial savings to a W.C.C. fund to support pilot energy projects in energy production in the developing countries.

(A draft plan and manifesto outlining the purpose and scope of the "Energy for my Neighbour" project is provided above which points to the need and the opportunity before the churches.)

The plan of action would be accompanied by a programme of information gathering and consultation to insure (a) the most effective participation of the cooperating churches; (b) the maximum use of information already available from the United Nations and other sources, evaluating alternative energy technologies.

The Core Group emphasizes that Church and Society is ready to cooperate in such a programme with any other agency in the W.C.C. in any way that is desirable.

Recommendations:

1. That the Central Committee of the W.C.C. endorse the action programme of the sub-unit on Church and Society, "Energy for my Neighbour", as a demonstration of solidarity with the need for a transition to a just, participatory and sustainable society.
2. Two regional consultations in developing countries on their energy policies and the responsibility of the churches to be convened in 1977 and 1978.

Ecumenical Programme of Research and Study on Energy for a Just and Sustainable Society

The Ecumenical Hearing on Nuclear Energy (Sigtuna, 1975) has provoked a large response in the churches and outside. In view of the many divergent views on nuclear energy and possible alternative energy sources, the Core Group urgently recommends that the World Council of Churches continue its efforts to interpret the issues and place them in a world-wide ecumenical perspective.

There are only three possible sustainable sources of energy – solar power, nuclear fission, and nuclear fusion. None of the existing technologies for solar power and nuclear fission provide sustainable sources of energy. Controlled nuclear fusion does not yet exist as a source and may never exist. Solar energy is at present only available for low temperature use and in small units. Existing types of nuclear fission plants would exhaust world supplies of uranium within a relatively short period. Sustainable supplies of energy are therefore dependent upon new types of fission plants that are economical in use of fuel (e.g. the breeder reactor at present under development) and that are safe; developments in solar power (including the use of green plants as a source of fuel); and the possibility of fusion. Each of the possible sustainable sources of energy face major developmental problems. All have particular difficulties and advantages, economically, environmentally, politically and technologically. In the meantine petroleum and natural gas will soon be gone. Coal is an important source of energy during the transition to a sustainable source, but its use also presents many problems.

In conclusion we recognize the necessity to

- maintain nuclear power as a viable option for the world whilst recognizing the necessity of resolving the paradoxes on nuclear power before a world-wide commitment becomes irreversible;
- develop alternative sustainable options to nuclear power, particularly solar energy and such regional sources as wind, wastes, and waves;
- reduce energy consumption in the industrialized countries.

The Core Group has explored these issues at its meeting and submits its report on *Energy for a Just and Sustainable Society* for the consideration of the Central Committee.

Recommendations:

1. **Nuclear Energy.** The long-run search for new sources of energy will involve the further development of nuclear energy. The strategic choices (between various types of breeder reactors) will be explored by many industrialized countries during the coming decade. The Church and Society programme should include an assessment of the particular problems that will be encountered, including social problems involved in the siting of these reactor and the safe management of the fuel cycle.
2. **Solar Energy.** The W.C.C., through the sub-unit on Church and Society, should actively investigate and report the social implications of feasibility studies that are presently being conducted on large-scale solar energy conversion and work for the removal of commercial constraints on access to this technology.

3. The W.C.C. through the sub-unit on Church and Society should continue to participate in current initiatives to further evaluate the role of nuclear power and should attempt to communicate the results of this process to the International Atomic Energy Agency (IAEA) and to the churches. (An abstract of the social and ethical issues to be presented to the IAEA Conference on "Nuclear Power and its Fuel Cycle", to be held in Salzburg, May 2-13, 1977, was submitted to the Central Committee.)
4. The Church and Society programme should also actively examine world fossil fuel strategies and report on their ethical and political implications as well as their social benefits and costs.

Note: The Core Group has proposed a small Energy Advisory Group to assist the sub-unit on Church and Society in the development and implementation of this reflection-action programme on energy for a just and sustainable society.

Dr Shem Arungu-Olende (Kenya)
Electrical Engineer and Energy Specialist, Centre for Natural Resources, Energy and Transport, United Nations, New York

Prof. H.B.G. Casimir (Netherlands)
President, European Physical Society; President, Royal Dutch Academy for the Arts and Sciences

Dr John M. Francis (U.K.)
Senior Research Fellow in Energy Studies, Heriot-Watt University, Edinburgh

Dr William Nashed (Egypt)
Industrial Training Adviser, United Nations, Riyadh, Saudi Arabia

Prof. David Rose (U.S.A.)
Professor of Nuclear Engineering, M.I.T., and Consultant to the Office of Technology Assessment, U.S. Congress

Dr Jorge Sabato (Argentina)
Physicist and former Member of Atomic Energy Commission

Prof. Roger L. Shinn (U.S.A.)
Professor of Social Ethics, Union Theological Seminary, New York

Dr K.T. Thomas (India)
Director, Engineering Services Group, Bhabha Research Centre, Trombay.

D. Allocation of Resources Beyond the Control of National Goverments

The Nairobi Assembly emphasized the need for the churches to be concerned about "the allocation of common resources not yet claimed by particular nations". These include the exploitation of the sea-bed, and other regions currently beyond the control of national governments or inter-governmental agencies.

Recommendation:

That a watching brief be kept on proposals for use of what are at present "international commons", e.g., the sea-bed. The immediate need is protection of such areas with a view to a fair distribution of the resources they contain.

E. National and Private Ownership of Resources

The need for a more just distribution of the earth's resources challenges the concept of the national and private ownership of these resources.

Recommendation:

That Church and Society encourage an appropriate person (or persons) to write one or two exploratory papers on the subject for publication in ecumenical journals and study in the churches.

IV. SCIENCE AND FAITH AND THE VISION OF A NEW SOCIETY

The Nairobi Assembly identified two areas in the encounter between science and faith. One is in ethics. The application of scientific discoveries to human affairs raises ethical issues which science alone cannot resolve since science itself does not prescribe the good. The second area is the challenge of the Christian view of the creative activity of God in the world to the dominant scientific view of reductionism and materialism.

A. Theological and Ethical Dilemmas in the Biological Manipulation of Human Life

Recent discoveries in the biological and medical sciences raise new ethical questions in uncharted areas. Some of these have been pursued by Church and Society in the discussions of its Zürich consultation as recorded in *Genetics and the Quality of Life* (published in 1975, eds. Charles Birch and Paul Abrecht). The Nairobi Assembly in the report of Section VI urged the importance of pursuing this discussion into further areas of concern. To this end the following proposal is made:

Recommendations:

1. That a consultation be held on the theological and ethical issues involved in
   a. experimentation on human foetuses and transplantation of ova fertilized outside the body (*Genetics and the Quality of Life*, pp. 210-211);
   b. the future possibility of direct manipulation of human genes for the purpose of replacing deleterious by "normal" genes (*Genetics and the Quality of Life*, pp. 55-56);
   c. artificial prolongation of human life in terminal illness.

   The consultation should seek a greater understanding of the meaning and mystery of human life and death with the objective of providing a framework of ideas and values within which biological manipulation at the beginning and at the end of human life might be legitimately conceived. To keep the consultation small and specific, the subject of behavioural control is deliberately excluded.

   The consultation should consist of about 20 persons from the following disciplines: theology, ethics, reproductive physiology, molecular genetics, pediatrics, obstetrics and law.

2. That a watching brief be kept by Church and Society on the discussions amongst scientists for a moratorium on genetic engineering in micro-organisms.*) At an appropriate stage Church and Society should prepare an article for publication in an ecumenical journal to stimulate debate on this subject.
3. That a watching brief be kept by Church and Society on developments in control of human behaviour and the deterministic interpretation of human behaviour with a view to proposing the best time for a consultation. In the meantime, Church and Society might prepare material for a paper to stimulate thought on this subject.

(**Note:** The methods for controlling human behaviour at present used are chemical (drugs), physical (electrical stimuli), surgical and psychological. Studies of behaviour have led not only to methods of controlling behaviour but also to the new "socio-biology" popularized by Lorenz, Ardrey and Morris which is having a wide influence in its interpretation of human behaviour in deterministic terms.)

B. Science, Ideology and Faith: A Critical Evaluation of World-Views

The Consultation on "The Christian Faith and the Changing Face of Science and Technology" in Mexico City (August 1975) found that science and faith challenge each other at the levels of both doctrine and ethics. Science and technology have become dominant modes of thinking and action throughout the world, and create obstacles to the presentation and understanding of the Christian faith in most cultures. Also, in making possible large-scale interference by man with his environment, science and technology raise ethical problems which lie beyond the traditional insights of the Christian community. There are, therefore, practical, theoretical and spiritual tasks to be performed in exploring the relationship of nature, man and God. These include a critique of the dominant scientific world-view and the ideologies which depend on this, a reformation of theology to take account of its situation vis-à-vis science, and a reintegration of Christian and scientific world-views in a way that will illuminate both doctrine and ethics.

Characteristics of the Scientific World-View

Science has often in the past been characterized by a mechanist, reductionist and determinist cosmology drawn largely from the triumphant physical sciences. It is still largely characterized by instrumental, pragmatic and impersonal values, and by a secularist ideology that excludes God from the universe and believes in automatic progress in history. At the same time, and increasingly in developed societies, the absence of humane moral values in the operation of science and technology is coming to be questioned, and scientists themselves are searching for acceptable goals for the use of science. While today scientific theory has gone beyond mechanist cosmology, the latter is still adhered to by many scientists and decision-makers. The traditional polemics of science against faith to which the cosmology gave rise are still seen as a problem among two sorts of groups: (a) in parts of the Church where fundamentalism is influential, and (b) among our contemporaries who still believe that science has disproved religion.

(*) At present research in "genetic engineering" is confined to micro-organisms in which genes can be transferred from one micro-organism to another. A hazard in this research is that new micro-organisms virulent to man could be accidentally produced with possible disastrous consequences, hence the call by some for a moratorium on such research.

A Unified View of Man and Nature in the Perspective of Faith

Few now believe that science can yield all knowledge or solve all problems of man and society. In the consequent ideological and moral vacuum, many look to religious faith for answers. But the legacy of scientific secularism has had difficulty in accepting traditional values and beliefs associated with Christianity. In any case, Christianity grounded its moral principles in theological principles, and here we must realize that theology itself is in serious disarray. It has no relevant value-system to present in the ethical debates about science; it has no unified cosmology of man and nature; and it has lost its nerve with regard to its own methods and the rational justification for its traditional formulations of belief. Therefore, the ethical and cosmological challenges from science should force theology to re-examine its own principles.

To respond to this challenge, theology needs to rethink its doctrine of man and nature. Also, scientists who are Christians need to be able to integrate their views of nature and man drawn from science, with their faith in the God of nature and man. Theology is at present badly equipped to satisfy this need. The Old and New Testament show that there is an integral relation between individual men, society and nature. However, this conceptual unity was disrupted in the 17th century – a disruption which led, on the one hand, to the possibility of man seeing himself as separate from objective nature and consequently to the development of natural science, and, on the other, to the retreat of religion and theology into the specifically human in detachment from nature.

Attempts to overcome this dichotomy are open to the danger of irrationalism and anti-science, as they try to put the clock back to pre-scientific ways of thinking. But this is not the answer. A new view of man in nature needs to take full account of scientific achievements and discovery and to develop new insights in science, and also to deepen theological insights into the relation of God and the world. Where can we look for these theological insights ?

In the Bible and in church tradition, God acts at two levels: in the community of men and women now and in all history, and also in the rest of the non-human universe which, after all, He created. The first of these two levels has been much discussed and generally accepted in Christian tradition but the second has not been fully understood nor accepted.

Some models of the relation of God to nature have been proposed: chance models, models of the Word and the covenant. But there is a need to go beyond the mechanism and materialism of many of these models to a reinterpretation in terms of a dynamic view of creation. Several questions arise about the relation of God, humanity and nature:

i. What is God's relation to nature ?
ii. What is the relation of humanity to nature? Is nature only the stage on which the drama of human life is performed ? Is man subject to nature, or master of it, or pertner with it ? What attitudes follow from these varying conceptions?
iii. Does non-human nature participate in any way in the salvation wrought in Christ ?

In the attempt to develop theological insights into these questions, it should not be forgotten that the very language of theology is also challenged, and that unanalyzed theological jargon often fails to communicate meaning. We now have the possibility of theological renewal not in inward-looking technical discussion, but in the context of current problems, where the agenda is presented from the community of faith and also from the secular world.

Science and Ideologies

Theological formulations have usually been defined in history in situations of conflict between the community of faith and surrounding alternative ideologies. Some influential ideologies of our day are Marxism, liberal humanism, and the faith in scientific-technological solutions. Marxism has both a systematic philosophical framework and a political power-base, and is greatly influential in theory and practice in many parts of the world. Like liberal humanism and faith in scientific solutions, Marxism also arises historically from the scientific movement of the 17th and 18th centuries. All three ideologies have made positive contributions, but are subject to the Christian critique of the scientific world-view. Some of these ideologies are especially relevant to views of the nature of man, with consequences for the stewardship of nature, for personal freedom, and for the sanctity of life and death. Many of the conceptions of these ideologies have permeated the Church. It therefore seems important that these views of man and nature should be made explicit in W.C.C. discussion, and consideration should be given to their consistency with new reflections upon Christian faith.

Learning from Other Cultures

The cultures which have not shared the scientific history of the industrialized world, are increasingly affected by the modes of thought and technology which the scientific movement has produced. Thus the critique of the scientific world-view and reformulations of theology and ethical principles required are as relevant to them as to the developed world. At the same time, their own indigenous cultures often include insights into more unified relations between God, men and nature which can contribute to these reformulations.

Recommendation:

That Church and Society convene one or more consultations on *Science, Ideology and Faith: A Critical Evaluation of World-Views;* dealing with the following interrelated topics:

1. A critical evaluation of the scientific world-view, together with its consequences for the current ideologies of liberal humanism, scientific-technological progress, and Marxism.
2. What insights are available in the traditional cultures of the developing world towards renewal of man's relation to nature ?
3. A self-critique of theology, with special reference to the question of how nature should be understood in relation to God and man.
4. The concept of the Just and Sustainable Society and the new thinking about science, technology and economics which it requires raises many questions about traditional values dominant in a technological and growth-oriented society. New thinking in Christian ethics is urgently needed on these many issues.

These consultations will require at least two years of careful preparation and involve the participation of scientists, philosophers, and theologians. Younger scientists and science students should be included among those invited to these consultations. It is also recommended that an ecumenical conference should be organized specifically for science and technology students on the issues of Faith, Science and Society. Other sub-units in Unit I are expected to join in the development of this programme on Science and Faith.

APPENDIX I

List of Participants, Core Group Meeting, Glion, Switzerland, May 15-20, 1976

The Core Group met in the Hôtel Righi-Vaudois, Glion, Switzerland, May 15-20, 1976. The meeting was chaired by Prof. Charles Birch (Australia) and the following members were present:

I. Members of the Working Committee (Core Group)

BIRCH, Prof. L. Charles
Interim Chairman
Challis Professor of Biology, University of Sydney, Australia

ARUNGU-OLENDE, Dr Shem
Center for Natural Resources, Energy and Transport, United Nations, New York, U.S.A.

DOXIADIS, Prof. Spyros
President, Institute of Child Health, Athens, Greece

GREGORIOS, Metropolitan Paulos
Principal, Orthodox Theological Seminary, Kottayam, India

HESSE, Prof. Mary
Professor of History and Philosophy of Science, University of Cambridge, U.K.

IHROMI, Mrs T.O.
Lecturer in Sociology, University of Jakarta, Indonesia

de LANGE, Dr H.M.
Director, Academic Institute for Fundamental Training in Industry, Rotterdam, Netherlands

SHINN, Prof. Roger L.
Professor of Social Ethics, Union Theological Seminary, New York, U.S.A.

(Dr. Günter Scholz, biochemist from East Germany, was unable to be present for personal reasons.)

II. Consultants

a. Nuclear Energy Issues:

FRANCIS, Dr John M.
Senior Research Fellow in Energy Studies, Heriot-Watt University, Edinburgh, U.K.

OPELZ, Mrs Merle
International Atomic Energy Agency, Geneva Office

ROSE, Prof. David J.
Professor of Nuclear Engineering, M.I.T., U.S.A.

THOMAS, Dr K.T.
Director, Engineering Services Group, Bhabha Atomic Research Centre, Trombay, India

TIBELL, Dr Gunnar
Swedish Physicist, working with the European Nuclear Research Centre (CERN), Geneva

b. Risk Assessment and Alternative Technology:

NWOSU, Dr B.C.E.
Executive Secretary, Natural Sciences Research Council of Nigeria

RAVETZ, Dr Jerome B.
Secretary, Council for Science and Society, London, U.K.

c. **Science and Faith:**

LYONS, Ms Cathie
Assistant General Secretary, Health and Welfare Division, Board of Global Ministries, United Methodist Church, U.S.A.

SIEGWALT, Prof. Gérard
Professor of Dogmatics, University of Strasbourg, France

III. **Staff**

ABRECHT, Dr Paul	Church and Society
BAUSWEIN, M. Jean-Jacques	Communications
STALSCHUS, Miss Christa	Church and Society
VISCHER, Dr Lukas	Faith and Order

APPENDIX II

Decisions of the Central Committee of the W.C.C. concerning the Programme of Church and Society (August 1976).

The Central Committee meeting in Geneva, August 10-18, 1976, agreed on the following programme recommendations for the sub-unit on Church and Society:

1. The focus for post-Nairobi study in this sub-unit itself should be: "The Contribution of Faith, Science and Technology in the Struggle for a Just, Participatory and Sustainable Society". It is urged that there be more emphasis on the social sciences and social technology.

2. In this context, the main task of the sub-unit is to plan the proposed World Conference on a Just, Participatory and Sustainable Society. This Conference will necessarily involve a substantial contribution of many sub-units (especially those of Unit II) and a significant contribution also from the sub-unit on Dialogue to interpret the technological crisis in its relation to all ideologies and spiritualities. And the planning and educational process before and after the Conference must see that the Conference remains close to the existential questions of its concerned publics, and especially to those of the rank and file church members. Full use should be made by the Conference of related opportunities, such as professional meetings and U.N. conferences. Increased cooperation should be sought with Roman Catholic study groups working on problems of Faith, Science and Society.

3. The Central Committee welcomes the Review Committee's wish that study on Science and Faith, comprising also a critique of current scientific and technological world-views and their ideological implications should receive special attention in the period up to 1979. The Committee emphasizes the importance of seconded staff time for this part of the programme.

4. **Recommendations:** The Central Committee accepts the proposal of a World Conference as tentatively outlined by the Core Group on Church and Society and authorizes Church and Society staff and its Working Group to begin the preparations and provide a more detailed plan at the Central Committee meeting in 1977.

The Central Committee welcomes the plan to hold several small specialized consultations between now and 1979 on particular issues related to the main theme and considers these also as preparation for the World Conference. Two such consultations are planned for 1977:

a. An exploratory meeting on Science, Ideology and Faith, a critical evaluation of world-views;

b. a consultation on energy carrying forward the discussion within the churches on the social and ethical implications of nuclear power and alternative energy systems. This would be a follow-up of the recently published report on "Energy for a Just and Sustainable Society".

The Central Committee recommends that Church and Society consult with the relevant sub-units in Unit II regarding the implementation of the proposed action programme – "Energy for my Neighbour" – and report to the Executive Committee in spring 1977.

From **Radical Technology**, edited by Godfrey Boyle and Peter Harper; Wildwood House, London, 1976.

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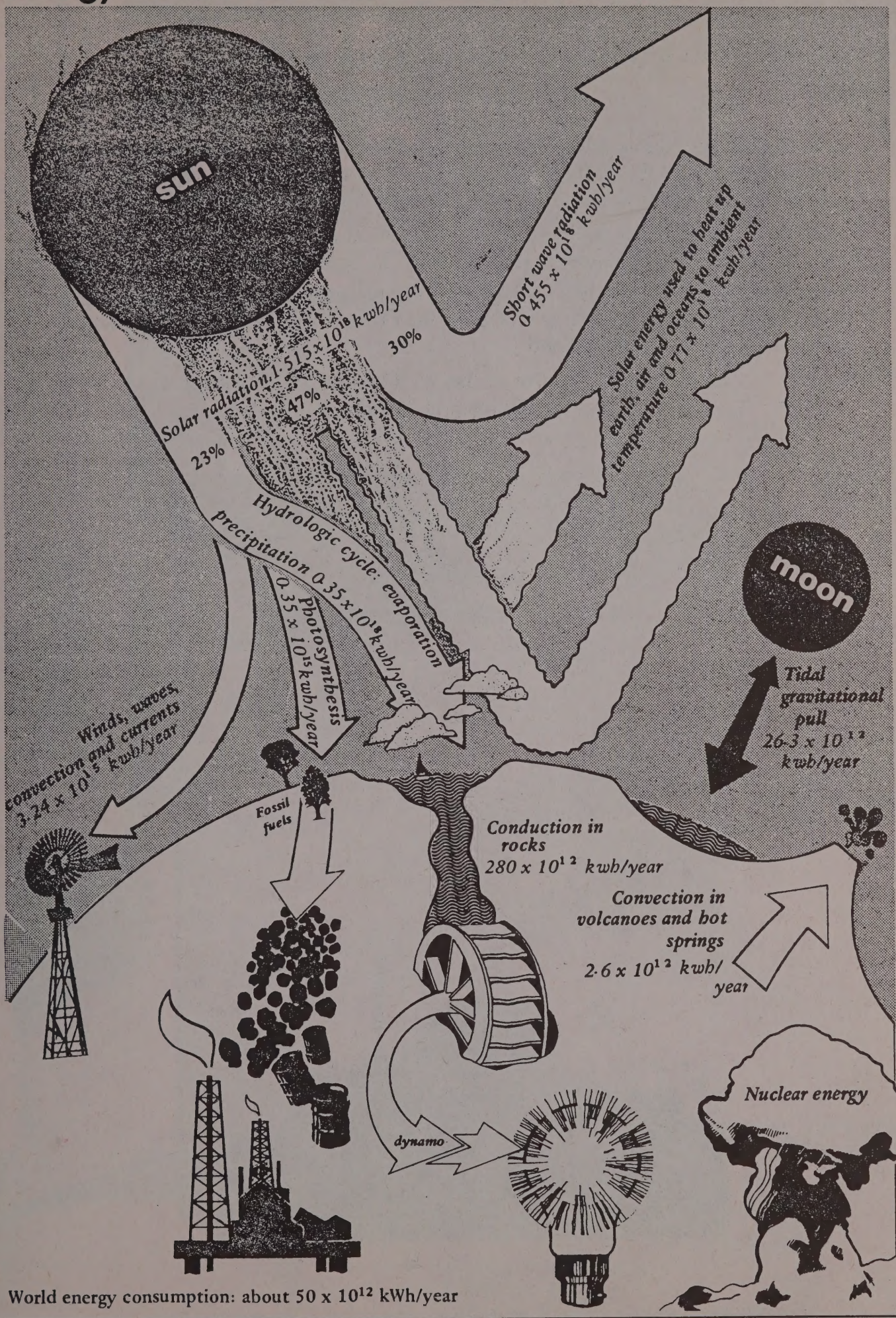

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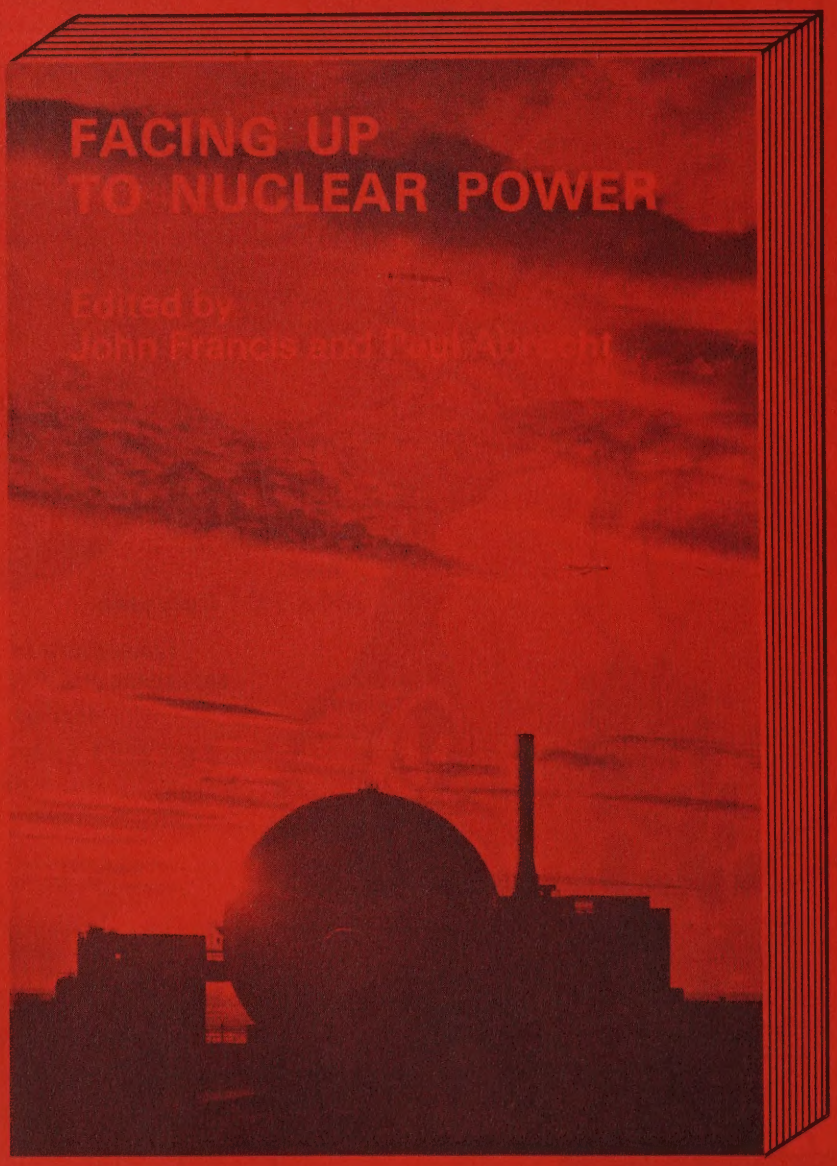
John Francis, one of Britain's distinguished young nuclear scientists; and recently senior research fellow in energy studies at the Heriot-Watt University Institute of Offshore Engineering in Scotland.

Paul Abrecht, Director of the World Council's Department on Church and Society.



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